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A DICTIONARY

OF

SCIENCE, LITERATURE, AND ART.

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A DICTIONARY

OF

SCIENCE, LITERATURE, & ART:

COMPRISING

THE DEFINITIONS AND
DERIVATIONS OF THE SCIENTIFIC TERMS IN
GENERAL USE, TOGETHER WITH THE HISTORY AND DESCRIPTIONS OF THE
SCIENTIFIC PRINCIPLES OF NEARLY EVERY BRANCH
OF HUMAN KNOWLEDGE.

NEW EDITION,

EDITED BY

W. T. BRANDE, D.C.L. F.R.S.L. & E.

LATE OF HER MAJESTY'S MINT

AND THE

REV. GEORGE W. COX, M.A.

LATE SCHOLAR OF TRINITY COLLEGE,
OXFORD.

IN THREE VOLUMES.

VOL. III.

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ADVERTISEMENT

TO

THE THIRD VOLUME.

THE PUBLICATION of this Volume has been delayed, in part by difficulties inseparable from the vast range of the work, but chiefly by the lamented death of Professor BRANDE, under whose care the first edition of this Dictionary was published six-and-twenty years ago. In recording his sincere regret that Professor BRANDE was not permitted to see this edition carried through the press, the Editor expresses a feeling which will be shared by all who knew him. The singular clearness and energy of mind, which enabled him to continue his editorial labours at the age of eighty years, seemed to warrant the hope that he might live to see the reappearance of this work in a form suited to the more stringent requirements and the wider knowledge of the present time. Although this was not to be, he yet had the rare happiness of being able to carry on his work to the eve of his death.

Professor BRANDE had thus in great part revised the articles which relate to his own subjects; but his editorial duties have since his death devolved on the present Editor, who desires now to acknowledge gratefully the ability with which the contributors have performed each his allotted task. The fulness and accuracy with which they have treated their several subjects render it necessary only to express a hope that throughout the book, and especially in all controverted or doubtful matters, the articles may be found to exhibit a judicially strict impartiality, which, while stating indifferently the opinions maintained by conflicting schools or parties, leaves it to the reader to draw his own conclusions from the evidence of facts laid before him.

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DICTIONARY

OF

SCIENCE, LITERATURE, AND ART.

Poles and Polars. The locus of the harmonic centres of the $(n-r)^{th}$ order, taken with respect to a point or *pole* o, of the n intersections of a given curve C_n by a transversal which constantly passes through o, is called the r^{th} *polar* of o with respect to the given (*primitive*) curve C_n. It is itself a curve of the $(n-r)^{th}$ order [HARMONIC CENTRES], and possesses very important properties. Each point in the plane, therefore, has $(n-1)$ distinct polars of the orders $n-1$, $n-2$, . . . 2, 1, respectively. The last or $(n-1)^{th}$ polar is called also the *polar line*, and the last but one or $(n-2)^{th}$ the polar conic, or quadric, the $(n-3)^{th}$ polar the polar cubic, and so on. From the properties of harmonic centres it follows at once that any polar of a point o is itself a polar of the same point with respect to each of the systems of polars of higher order than itself. Thus the r^{th} polar of o with respect to C_n is at one and the same time the $(r-1)^{th}$ polar of the 1st polar of C_n, the $(r-2)^{th}$ polar of the 2nd, the $(r-3)^{th}$ polar of the 3rd, and so on. As a special case the polar line of o with respect to C_n, is at the same time the polar line of o with respect to all the other polars of C_n, considered respectively as primitive curves. From the properties of harmonic centres, too, it follows that the locus of the pole m whose r^{th} polar passes through a fixed point o is the $(n-r)^{th}$ polar of o. Thus the polar line of o is the locus of all points whose first polars pass through o, and further, the first polars of all points of a line constitute a pencil of curves of the $(n-1)^{th}$ order, passing through the same $(n-1)^2$ points; these are the *poles* of that line. When the primitive curve is a conic, each point in the plane has, of course, but one polar, the polar line, and each line but one pole; in this case, too, the polar is simply the locus of the harmonic conjugate of the pole with respect to the points of intersection of the conic by any transversal through this pole. The polar of a point on the conic itself is the tangent at that point; indeed, generally, the polars of a point o situated on the primitive curve C_n, all touch the latter in o, the common tangent being, of course, the polar line of o. The first polar C_{n-1} of any point ρ is the locus of the points of contact of all tangents drawn from o to the primitive curve; so that $n\,(n-1)$, or the number of intersections of C_n and C_{n-1}, is the maximum, and in general the actual number of such tangents; this number, therefore, indicates the *class* of the curve. Should the primitive curve possess multiple points, however, every first polar will pass through them, and the $n\,(n-1)$ intersections of the latter with C_n will not all be the points of contact of tangents from o. Thus if C_n has a double point at d, the 1st polar C_{n-1} of o will pass through it, and be there touched by the harmonic conjugate of $d\,o$ with respect to the two tangents to C_n at d. This point d, therefore, will count for *two* amongst the $n\,(n-1)$ intersections of C_n and C_{n-1}. If C_n have a cusp at c, C_{n-1} will not only pass through it, but will be there touched by the cuspidal tangent, so that c will count for three amongst the intersections of C_n and C_{n-1}. We thus arrive at the result that the class of a curve of the n^{th} order, which has d double points and k cusps, is $n\,(n-1)-2\delta-3\kappa$. This is the first of Plücker's well-known equations. [SINGULARITIES OF CURVES.]

The subject of poles and polars will be found treated algebraically in Dr. Salmon's *Higher Plane Curves*, and geometrically by Steiner in Crelle's *Journal*, vol. xlvii. 1854, and by Cremona, in his *Teoria geometrica delle Curve Piane* (Bologna 1862).

Poles and polars with respect to surfaces have a precisely similar definition. Their numerous and very important properties are treated with great ability by Dr. Salmon in his *An. Geom. of Three Dimensions*.

Pole-axe. A long axe much used as an offensive weapon in the middle ages. It ap-

pears frequently in the Bayeux tapestry. [BATTLE-AXE.]

POLE-AXE. In the Navy, a heavy hatchet having a handle fifteen inches long, and a sharp point bending downwards on the side opposite the blade. It is used in boarding or resisting boarders, for the purpose of cutting ropes or nettings, and as a weapon.

Pole-mast. A mast consisting of one piece of timber as opposed to a made-mast, which is built of several pieces ringed together.

Polecat. The *Putorius fœtidus* of zoologists. It is common in England, where its white variety (*P. fœtidus furo*) is often domesticated under the name of ferret. The ferret and polecat readily intermix to the production of a fertile offspring.

Polemarch (Gr. πολέμαρχος). A name applied by the Greeks to magistrates intrusted with the military affairs and expeditions of a state. Such offices are found in Sparta and some Bœotian cities; at Athens the polemarch was one of the nine archons. [ARCHON.]

Polemoniaceæ (Polemonium, one of the genera). The name of a natural order of perigynous Exogens referred by Lindley to the Solanal alliance. They are mostly herbs, some of them being ornamental garden plants, and are distinguished by having five free stamens, axile placentæ, and straight plano-convex cotyledons. It comes near *Hydrophyllaceæ*, but the placentation is different. Among the genera which are esteemed in gardens may be mentioned *Phlox* and *Polemonium* as herbaceous perennials; *Gilia*, *Leptosiphon*, *Collomia*, and *Ipomopsis*, as annuals and biennials; and *Cobœa* and *Cantua* as greenhouse plants. In *Collomia* the mucous covers of the seed consist of an infinite number of delicate spiral vessels, which form a kind of cloud around the seed when it is thrown into water, by their rapid uncoiling and extension.

Polemoscope (Gr. πόλεμος, *war*, and σκοπέω, *I view*). An instrument, imagined by Hevelius, for seeing objects which cannot be seen by direct vision. It consists of a mirror placed obliquely in a tube or box, having an opening in the side opposite the mirror, so that rays from any object falling on the mirror are reflected to the eye of the spectator. Hevelius chose the name of *polemoscope* because he thought the instrument might be applied, in time of war, to discover what was going on in the camp of the enemy, while the spectator remained concealed behind a wall or other defence, and therefore could not employ a telescope. Opera-glasses are sometimes constructed on this principle, for the purpose of enabling a person to see others on the right or left, while he appears to look straight forward.

Polenta (Ital.). Corn meal mixed with cheese and made into a kind of pudding forms a dish which the Italians call *polenta*. The article sold in London under the name of polenta is the meal of Indian wheat or maize.

Polhode (Gr. πόλος, and ὁδός, *a route*). A quartic curve of double curvature which may be defined as the locus of the point of contact with an ellipsoid of a tangent plane common to it and a concentric sphere. The curve owes its name to Poinsot, who employed it in his remarkably lucid exposition of the rotation of a body around a fixed point. [ROTATION.] It is a closed curve whose axis of symmetry is the major or minor axis of the ellipsoid, according as the radius of the concentric sphere is greater or less than the mean semi-axis. When this radius and the mean semi-axis are equal, the polhode degenerates into two equal ellipses whose planes intersect in the mean axis. The orthogonal projection of a polhode on the plane of the major and minor axis of the ellipsoid is always a hyperbolic arc, and of its projections on the other two principal planes, one is always an ellipse, and the other an elliptic arc. If a, b, c, h, represent, respectively, the semi-axes of the ellipsoid, and the radius of the sphere, the polhode is obviously represented by the two equations

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1,\ \frac{x^2}{a^4}+\frac{y^2}{b^4}+\frac{z^2}{c^4}=\frac{1}{h^2},$$

from which the above, as well as all other properties of the curve, may be readily deduced. For the associate of the polhode, in Poinsot's theory, see HERPOLHODE.

Polianite (Gr. πολιός, *grey*). A deutoxide of manganese, differing from Pyrolusite in its greater hardness and pale steel-grey colour. It occurs in short and vertically striated right-rhomboidal prisms, also in granular masses, in Bohemia, Saxony, Thuringia, Siegen in Prussia, and also in Cornwall.

Police (Gr. πολιτεία, *government*). This term is used to designate those minor but highly important functions of administration, by which protection is afforded to persons and property; crime and outrage are prevented, or, if not prevented, detected; and lastly, public wealth defended by sanitary and other regulations. The maintenance of these and other social advantages or necessities is a matter of police; though, in fact, the word is commonly employed in a narrower sense for the constabulary force, which, superseding the relics of the old manorial or parochial system, has been very effective in the performance of some among these functions.

The ancient police was the view of frankpledge, and the superintendence of the manor court. [MANOR.] When this system became obsolete, the constable or tything man, and the watchmen in towns, became the very inefficient conservators of the public peace. The author of the modern English police force was the late Sir Robert Peel, whose legislation in this direction has been stereotyped in the vulgar name given to the policeman, *peeler*. The police force is either open or secret. The ordinary policeman is dressed in a particular uniform, known to everyone, and his operations are limited to a particular region called his *beat*, and which has been handed down from the days of the watchmen. A secret police is one which is distinguished neither by dress nor demeanour from ordinary citizens, and its duty is to detect crime,

and if possible to prevent it, by obtaining all such information as could not be arrived at by any ordinary method. There is, of course, some danger lest a secret police should stimulate the crime which it is employed to prevent, and there is little doubt that in old days the detective was too often the master of thieves. A secret police employed for political purposes is the most odious form which the detective may assume, and that which is most likely to be turned to the worst ends.

The metropolitan police is under the general management of a public officer whose head office is in Scotland Yard. The city police is, however, controlled by the corporation, and a late attempt made to amalgamate the two forces has been baffled. The police in towns is generally under the control of the municipal authorities, while the chief officer of the county police is the chief constable of the county. The police system has been gradually extended over the whole country.

The police in Ireland is different from that in England, being armed, and generally of a military character. The apology for such a force, with duties divergent from those supposed to belong generally to civil officers, has been found in the disturbed state of Ireland, and the frequency of outrages. In 1862, the police force of the city of London was 628, of the rest of the metropolis 6,566, of the boroughs 6,286, of the counties 7,969, of the dockyards 712. Total for England and Wales, 22,161; and the cost was 1,596,994*l.* Towards this charge 385,701*l.* was contributed from the Treasury.

Policy. This word, as applied in Life Assurance, is in Mr. Wedgwood's opinion (*Dictionary of English Etymology*) a violent corruption of the Greek πολύπτυχον, sc. γραμματεῖον, *tablets folded into many leaves*, which were used when the Diptych was not large enough to contain the writing. The word is found in the transition forms *puleticum, polaticum, potlegium*. [Assurance.]

Polishing (Lat. polio, *I make smooth*). In Sculpture, the operation of giving a smoothness and gloss to any surface. The polishing of marble is effected by first rubbing the surface with freestone; after which it is wrought upon with pumicestone; and lastly with the finest emery powder, from which the glossy surface is obtained.

Polishing Slate. The *Polierschiefer* of the German mineralogists. A light slaty substance found abundantly at Bilin in Bohemia: it consists of the silicious shields of microscopic animals.

Political Arithmetic. In the works of the earliest economical writers, as Petty, Davenant, and Gregory King, this term was employed to designate the science which now goes under the name of *political economy* or economic science. In fact, the greater part of the theories alleged by these writers were founded on numerical calculations, and very few of their works contained the enunciation of principles, and the vindication of rules. In later times political arithmetic is identified with Statistics.

Political Economy. The science of those forces which operate upon the social faculties of man, in so far as the products of such faculties and forces are in demand, and may be estimated by some recognised measure of value. Political Economy is generally defined as the science of the laws which govern the production, distribution, and consumption of wealth; but most of the terms employed in this definition are ambiguous. Wealth is sometimes used for the sense of satisfaction felt by an individual in his ability to procure anything which he may desire; sometimes for the comparative capacity of nations stimulated to acquisition, not only by the impulse to individual gain, but by mutual rivalry. Again, wealth is sometimes used for a product, and is therefore limited to material objects, sometimes for a state, in which powers as well as products are reckoned. Again, the word *production*, though the least ambiguous of the technical terms which comprise the common definition, is variously interpreted; sometimes as containing mechanical labour only, sometimes as embracing the training of mechanical labour, rarely as including all the subsidiary processes, by which mechanical labour is rendered efficient, continuous, and trustworthy. The term *distribution* is also equivocal; it stands with economists for the portion which the several members of society receive as their share out of the gross produce, but it may also mean, and often does mean, the method by which the products of one kind of labour are exchanged against the products of another kind. And lastly, consumption is either productive or unproductive, the former being understood to mean that application of the profits of labour which is destined for future production, the latter such expenditure as is not so destined. But as rest is as essential to the continuity of labour as exertion itself, we can scarcely maintain (unless the expenditure be vicious or mischievous) that consumption, ostensibly unproductive, is not or may not be indirectly a means, and a necessary means, for future production. And thus it may be said, that although the definition commonly given by economists, is sanctioned by custom and authority; its exceedingly ambiguous character is continually provoking discussion as to the fundamental limits of the science, and involving the repetition of a number of cautions which need not be given, were the terms by which political economy is to be defined, rendered sufficiently distinct and clear.

Political economy is a science, i. e. it deals with laws uncontrollable by human volition, and with phenomena derived by inevitable sequence from these laws. In common language, we may speak of the violation of an economical law. By this we mean merely, that the occurrence of one course of action will give rise to certain phenomena, and the adoption of a contrary course will be followed by contrary phenomena. On the hypothesis of in-

dustry, i.e. of a desire for material improvement, the adoption of free trade will be followed by material prosperity, while every act which hinders the voluntary energies of men is pro tanto a bar to material progress. The rise follows the other as certainly as vegetation springs from light, heat, and moisture, and as the cessation of organic growth is the result of cold, darkness, and drought. Free exchange, in short, is a fundamental condition in political economy. We can indeed interpret, in the presence of limitation violently put on economical action, what will be the material consequences, but we cannot judge or predict the benefits of free action, unless we have experience of the results which ensue from its unshackled adoption. The real benefits of freedom can be understood only by its extension, and as yet the most advanced public policy has only entered upon the vestibule of its temple, and had experience of a part of its operation.

The elements with which economical action deals, are those which reside in materials bestowed by nature. If these elements are limited, as those of land in settled countries, water in motion, and the like, a demand may arise for them on their appropriation, from the very fact of their being limited, and this appropriation may take place, irrespectively of the quantity which may be used, by any municipal regulations which prevent occupation. If they are unlimited, their value is derived from the labour bestowed on their appropriation. Thus the force of wind, the power of steam, and the like are unlimited elements; but in order that they may be rendered available, labour must be bestowed upon their use, and thus they become valuable, not in themselves, but because they have become products of labour. The forces which stimulate the faculties to make such an appropriation, are partly personal and partly social; personal in so far as self-interest is the motive principle of all economical labour, social because the largest individual benefit is derived from the most complete reciprocity of services. Hence the true growth of economical principles leads to the fullest international association, and the closest identity of all such interests as can possibly be made of reciprocal benefit. Every man who wishes to exchange comes with a benefit to the other man with whom the exchange is to be effected; each person is a buyer, each a seller, and each values that which he receives at a higher rate than he values that which he bestows. If the object received be of no greater value than that which is offered, no exchange takes place; and therefore the doctrine that a foreigner's gain in trade with any country is a loss to the country trading with him, is a position as false as it is mischievous. In order that the object should be desirable, it must needs have had labour expended on it. No man will give of his own, in order to obtain some other thing which is as much in his possession as it would be in any other man's. Under certain circumstances, indeed, it does not follow that the individual's labour must be hard; it may be exceedingly slight; but the value of the article which he offers must be proportioned to the average amount of labour expended on its production. A man may procure, perhaps, by the mere labour of stooping to pick it up, a diamond worth 10,000*l.*, but it is worth so much, not because of the amount of labour which he has bestowed, but because it takes on an average ten thousand pounds' worth of labour in order to obtain a similar stone.

Furthermore, the utility or service or benefit, must be appraised by some standard. This is, as we know, familiarly, money. Not that money itself is useful to the individual; it is a pledge, taken because certain to be redeemed, that the future demands of the recipient can be satisfied with it. But the use of a measure (even though no money actually passes, but only a debt or credit in behalf of the seller is created) is necessary for commercial transactions. It may be doubted whether any progress can be made in civilisation without some such medium, that is, at least, without some habitual estimate of values by a recognised standard. At any rate, the existence of such a standard is discoverable in the earliest civilisation. Many services may be rendered to mankind, the value of which is immense, but the commercial estimate of which is necessarily wanting. No compensation can be made for wise statesmanship, for sound instruction in public and private duty, for rectitude and integrity of life, for the qualities which we venerate and trust. [LIBERTY.] Without them, the world would be a desert inhabited by a few savages; with them it becomes possible that the maximum number of the human race should subsist with the maximum of comfort and convenience. They are therefore postulates of the best economical state, but they are not appreciable values, because no measure of the service can be rendered in money or money's worth, because moreover they are not subsequent on any demand, but precede it, by the fact that they enlighten society as to the fundamental and permanent advantage of moral goodness. Truth, honour, and virtue cannot be taken into account by an economist, because, valuable as they are, they cannot be economically estimated; but no one except a doctrinaire would forget or ignore them.

Moralists are well acquainted with the influence of two coexistent springs of action: (1) that which lays down an external standard of action, which impels towards community of sentiment and action, which acts upon conscience and conviction; and (2) that which is a mere logical interpretation of objects according to the dictates of personal interest or convenience. To say that both are equally busied with the interpretations of personal utility is an abuse of terms, for the distinction between the two is fundamental in civilised thought and language. To say that they coincide in the best practice of human life is to admit what all would anticipate, the fact, namely, that natural impulses

are capable of mutual harmony. It is part, therefore, of the great analytical utility and the wide practical sagacity of Adam Smith, that while he developed an economical theory from the personal or selfish instincts of man, he framed an ethical theory of human nature by ascribing morality to the force of human sympathy. It is true that this theory seems and is one-sided, but taken in conjunction with the economical aspect of man's nature, it will be found to give a more coherent estimate of ethics than is commonly found.

Political economy is to history what logic is to morals—the analysis, namely, of the conscious process by which a nation or an individual thinks and acts. Hitherto, indeed, the economical interpretation of history has made but little progress, partly because materials have been wanting, partly because the habit of historical enquiry has tended rather, in so far as the philosophy of history has been developed, towards legal, military, and diplomatic researches. But to take a few examples, the great political position of the Italian republics in the middle ages was entirely due to their economical position, to the fact of their being the financiers of Europe. Their rivals, the popes of the same epoch, were capitalists, whose resources were freely used for purposes of personal ambition or of diplomatic influence. The trade of Europe with the East, passing partly through Egypt, and partly through the valleys of the Tigris and Euphrates, over the highlands of Armenia to Trebizond, or southwards to Licia (i.e. Seleucia) was monopolised by the Genoese and Venetians. All this supremacy passed away with the simultaneous discovery of the Cape passage and the New World; and the voyages of Vasco da Gama and Columbus, purely commercial in their beginning, tended as much to the Reformation and the downfall of the ancient diplomatic centres, as any theological speculations or political changes. Similarly, the great position occupied by this country during the thirteenth and early part of the fourteenth centuries, is to be assigned far more truly to economical causes than to the disintegration of the French monarchy, and the decline of Italian liberty. During the long and obscure reign of Henry III., great social progress had been made in England. The harsher features of villenage had been effaced; and in all likelihood a minute search among the abundant materials existent for the economical and social history of the century contained in the reigns of the three Edwards would fail to discover any trace of actual slavery in England, or, indeed, anything but fixed labour rents commutable for money, and coupled with permanent tenure. A contrast between the condition of the English peasants and the material of the population of France would be quite sufficient to account for the military preponderance of this country during the period adverted to. Between the insurrection of the Jacquerie in the middle of the fourteenth century, and that of the English peasants at its close, there was, though they are regarded as similar events by Hallam, only a slight external resemblance—the former having been the uprising of desperate misery, the latter the attempted revolution of a prosperous class. In consequence the French peasant was forced back into still more abject servitude; the English occupier, baffled for a time, achieved his independence by the election statute of Henry IV.

In modern times, the laws and maxims of political economy are gradually becoming the staple of legislative and administrative politics, the business of government being more and more persistently directed towards the progress of economical prosperity, and the gradual extinction of practical errors. It is true that partly in consequence of the difficulty of persuading interests whose prosperity is likely in appearance to be compromised by changes, partly by the inherent conservatism of all administrations, and especially of those which are most despotic, and therefore most timid, the progress made is comparatively small; but to have begun at all is of no small consequence, and the general ventilation of economical questions is evidence that changes, the benefits of which are manifest and uniform, cannot long be delayed. Still more satisfactory, in this country at least, is the fulness with which economical laws are interpreted by society at large. For example, the cessation of supply from the cotton-producing districts in the United States, consequent upon the four years' war, completely paralysed the industry of a tenth part of the people in this country, and injured all by raising the price of a necessary of life. It may be confidently stated, that twenty years ago a like cessation of supply would have been followed by such discontent among the sufferers, as would have induced insubordination and riot, and the country would have witnessed on a large scale, during the recent cotton famine, excesses similar to the agrarian outbreaks of twenty or thirty years ago. As it was, all classes bore testimony to the patience with which the suffering was endured. It was endured, because the parties most interested were aware that the deficiency was caused by circumstances with which all administrative or diplomatic skill would be perfectly incompetent to deal—because, in other words, they were generally acquainted with the economical conditions of supply and demand. It may be hoped that, hereafter, the same acquaintance with the true relations of labour and capital will put an end to the unjust and mischievous operation of trades' unions, and that protected labour will be seen to occupy as immoral and indefensible a position as protected capital.

The great advantage supplied by an acquaintance with the laws of political economy lies in the fact that it determines distinctly what must happen from a course of commercial or social policy which is consonant with its precepts, or repugnant to them. It is a science, because it can predict with certainty the phe-

nomena which will ensue from a particular line of action, in so far as it has been hitherto possible to analyse the elements from which the result will come, and interpret and account for all the forces which contribute to the event. Of course it has its problems, and it has been the subject of hasty and erroneous generalization. But its leading and accepted principles are as certain as any other natural laws, and are as little liable to suspension or modification. It is because it is thus rigid and precise that political economy has been censured as a harsh, or, as Mr. Carlyle has called it, a dismal science. But we may as well call physiology a dismal science, because it points out the necessary consequence of violating sanitary or dietetic rules. It is of the highest value to know what are the limits of voluntary action, and what is the inevitable result of a natural law. For the contrast between the laws of political economy and the averages of statistics, see STATISTICS.

The various terms employed by economists, as CAPITAL, EXCHANGE, LABOUR, PROFIT, RENT, TAXATION, WAGES, will be found treated under their proper heads. The remainder of this article will be devoted to a short history of the progress of political economy, and its position in ancient and modern systems of practical philosophy, and to a summary of the causes and conditions of comparative wealth.

It was not likely that this branch of social science would escape the investigation of the Greek thinkers. It was not likely that it would, except to a very limited extent, form a material for original thought under the despotism of the Roman empire, or even of the Roman republic. The Greeks did not, it is true, separate this portion of ethical and political science, and erect it into a distinct subject of enquiry. For, in the first place, the sphere of individual action, and that of political obligation, were far more closely identified by the Greeks than they are with us. [LIBERTY.] They held that man exists for the community, while we in modern times are far more disposed to hold that the community exists for the developement of individual purposes, and for the harmony of individual ends. Hence they controlled the conduct, the occupations, and opinions of men more severely than would be thought consistent with that liberty which we know to be the only guarantee of a true civilisation. And in the next place, the Division of Sciences, though commenced by Aristotle, was not, in the comparative scantiness of human information, ever carried out as it is now. Such a division of science, like the division of labour, is the result of accumulated information gathered from large and varied fields of enquiry. But the chief and most central axioms of political economy can be found in the works of these fathers of mental science. The magnificent romance of Plato, his ideal republic, is founded on the familiar economical law, that the best results are procured by a progressive division of occupations. The Politics of Aristotle contain some of the soundest definitions which can be found of some among the formulæ of political economy; as for instance, those of the functions of money and of the necessity of reciprocal benefit in all operations of exchange. The introductory chapter to this work might form an exordium to an economical treatise. The relations of credit to capital are determined with tolerable exactness in the Eryxias, a dialogue printed among the works of Plato, and generally assigned to the Socratist, Æschines. Not that the theories held by those ancient thinkers were one and all satisfactory and sound. They were totally unacquainted with the cardinal distinction between profit and wages, and hence held, in common with most ancient writers and politicians, the unlawfulness of interest.

The downfall of the Roman empire is traceable in no slight degree to the practical defiance of economical principles. M. Guizot, in his *History of Civilisation*, has shown how the fiscal regulations of the empire were fatal to the prosperity of the provincials, and we all know how wide-spread was the evil of slavery in the ancient world. It would seem, too, that any economical reform in the public policy of the Romans was dangerous in the highest sense to those who proposed and furthered it. The fate of the Gracchi and of the schemes which they furthered for the social improvement of Italy furnished a stern warning to all innovators. The authors of a necessary reform, and of a set of economical changes which were absolutely obligatory for the preservation of the national life, were murdered by the aristocracy, and by a most perverse destiny their names have been thenceforward identified with sedition, confiscation, and robbery.

In this country, the history of the science of political economy is one of a perpetual contest against administrative error. The earliest writing on the subject is perhaps the essay once ascribed to Shakspeare, but now known to be the composition of one Stratford, in which the high prices prevailing in England are discussed and traced to tamperings with the currency, as well as to a general rise in money values. The works of Mun, the author of the mercantile system, and long the great authority in that branch of political economy which deals with commerce and the exchanges, were directed against the unwise prohibitions on the exportation of the precious metals, the absolute inability of the enactments against those who were indifferent to breaking the law, and the vexatious and mischievous interference of the officers who succeeded to the functions of the king's exchanger. This great officer (the first, appointed by Edward III., being William de la Pole, an eminent merchant, and ancestor of those dukes of Suffolk who played so important a part in the civil broils of the fifteenth century) was regularly nominated by patent, and entrusted with the duty of prohibiting the export of the precious metals. The last who had a valid patent was Lord Burleigh, but he never

exercised his functions. Charles I. appointed the earl of Holland in 1628, but the goldsmiths petitioned against the appointment, and Selden in the House of Commons disputed the validity of the patent.

Mun was far from doubting the general truth of the popular theory, that wealth consisted in gold and silver, and that the only way in which communities which had no mines of the precious metal could become rich, was by taking care that an excess of payments in these metals should form the characteristic of successful trade. But his experience had taught him that trade with the East was impossible, unless permission were given for the exportation of specie. The East had always supplied, by an expensive and precarious route, those tropical commodities which the fashion of the time, and the hardships of social life in the middle ages, rendered in the greatest degree convenient, if not almost necessary. But the producing countries could be led to acts of exchange only by the offer of the precious metals, particularly silver, for India produces these metals in very small quantities, and has always absorbed a vast amount for purposes of currency, of display, and still more largely, in all likelihood, for hoarding. Thus Mun argued that the relaxation of these prohibitions, as far as the Indian trade was concerned, was not only essential to the trade with those regions, but also in the highest sense advantageous to the country, because the sale of these imported commodities in European markets would certainly procure a far larger amount of specie than had been previously exported. Hence Mun has been considered the author of the balance of bargains or mercantile system, in which it was admitted that the business of trade was to enforce and support the theory that the precious metals are wealth, though the means whereby this wealth should be secured were to be circuitous. At any rate, the theory was accepted, and for more than a century acted on.

The works of Petty, Davenant, and Gregory King are rather statistical than economical, and though the writings of the first and last of these authors are full of sagacious and practical observations, they can hardly be said to have contributed much to the progress of the science. The same criticism may be applied to the speculations of the various writers on banking and the currency, speculations which led, when sound, to such an establishment as the Bank of England, at Paterson's instance, and when unsound, to the wild schemes of Chamberlayn and Law, and the fraudulent jobbery of the South Sea scheme.

The true founder of the modern system of political economy was Adam Smith. The *Enquiry into the Nature and Causes of the Wealth of Nations* was published in 1776. It was aimed specially at the refutation of the mercantile theory, the protective system, the regulation of commerce by protective enactments, and the colonial theories then in full operation. Adam Smith was the first of modern economists to show what are the true functions of money, and what is the consequence of those errors which identify it with wealth; he proved incontestably that the protective method then and long afterwards supposed to be the only just and patriotic course of policy, was neither just nor expedient, that the notion of government being able to direct an individual's commerce or expenditure more discreetly than he ordinarily could himself, would be utterly absurd, if it were not exceedingly mischievous, and that by the system of colonial trade, which strove to execute the invidious and malignant project of excluding other nations as much as possible from any share in it, England had not only sacrificed a part of the absolute advantage which she, as well as every other nation, might have derived from that trade, but had subjected herself both to an absolute and relative disadvantage in every other branch of trade. Adam Smith was also the first to lay down a consistent theory of taxation, and to determine from an economical point of view the functions of government; and though it cannot be asserted that he was invariably right either in his principles or in his inferences from them, yet his work possessed not only the great merit of being the foundation of the most important and significant of the practical sciences, but also that of presenting the largest amount of novel but complete refutations of inveterate prejudices that ever perhaps had been collected in any single volume, together with the most lucid illustrations of the principles and inferences laid down and deduced. But among the other merits of this great work we must not lose sight of its geniality and warmth. It is true that the point of view necessarily taken by Smith was the existence and stimulus of personal and material interests. But he finds these interests not in a narrow and selfish satisfaction, but in the harmony and reciprocity of all men's good. It is in this way only that the science can be freed from those repulsive traits which have been made too prominent in its treatment by less comprehensive and generous minds. For unless the mutual service of men, and the mutual duty of all the units of which society is composed, be understood and enforced, there is no escape from that passion for personal advantage, that protection to particular interests, and that selfish and suicidal disregard for the good of others, of which the *Enquiry into the Wealth of Nations* is the happiest, the most energetic, and the most complete refutation. 'Adam Smith,' says one of the ablest and most profound of modern philosophers, Mr. Goldwin Smith, 'understood the value, moral as well as material, of property, but he also understood the relative value of property and affection.' (*Lectures on the Study of History*, 2nd edit. p. 162.)

Idle and crude as now seem many of the fancies which were exploded by the appearance

of Adam Smith's great work, it would be an error to imagine that the first refutation was unattended with difficulty. It costs very much to shake off prejudices in thought as well as it does to correct unseemliness or uncouthness in action. It needs great courage, complete abstraction, and cautious attention to meet and go counter to the current of popular opinion. The convictions of one generation commonly become, it is true, manifest errors to another; yet not less ingenuity is needed for the first refutation of a vulgar error, than for the discovery of a physical law or a mathematical method. We should measure the value of Adam Smith's labours not by a comparison between the results of his argument, and the shape into which his successors have put the science of which he was the author, but by contrasting the science as he left it, and the host of fallacies which, universally accepted before his time, were destroyed at once by his sagacity. Mr. Mill has done justice to the intrinsic power of his predecessor by acknowledging the great progress made by Smith, and the epoch which it forms in human thought.

Many systems of political economy have followed that of Adam Smith. We may mention among continental writers J. B. Say and Sismondi; while in England the first to carry on the enquiry into economical science were Malthus and Ricardo. But in this country, these and other writers have been rather distinguished as promulgating views more or less accurate on special points connected with the general subject, than for any fresh arrangement of the science itself. Thus, for a reason already adverted to—the fact, namely, that political economy has been developed more from a polemical than from a constructive impulse, and that its growth has been due more to assaults directed against real or supposed errors in practice, than to positive elaboration and synthesis—Malthus is distinguished rather as the author of the theory of population, Ricardo as an authority on the subject of rent and taxation.

It would be tedious to recount the names of the several persons who have handled with various success the general theory of the science, and still more difficult to enumerate those who have made large additions in detail to the several divisions under which the material is arranged, or have contributed cognate or auxiliary information and reasoning. Enquiries into subjects which have an economical value and are open to an economical estimate, are of great importance in the progress of the science, not only because they serve to elucidate and interpret the various and intricate problems which perpetually recur, and furnish material for debate and decision, but because political economy needs to be constantly illustrated, and (if need be) corrected by facts, while there is and probably will be a continual disposition to transport it into the domain of abstract theory, and thus very often to avoid the limitations and corrections by which a theory must be constantly attended. Mr. M'Culloch's work on the *Literature of Political Economy* is one of great value, and might be advantageously continued to the present time.

Mr. Mill has avowedly proposed in his valuable and important work to remodel the theory of Adam Smith, on the principle which clearly guided the first founder of the science; i. e. to unite abstract reasonings with abundant illustrations, and to associate the subject with social and political philosophy. We cannot here attempt any criticism of Mr. Mill's method or principles, nor would it be possible to enquire how far he has carried out the plan with which he prefaces his work. It is sufficient to say that the great and undoubted merits of this author have given him almost the position of an arbiter on economical questions, and have caused his authority to be eagerly appealed to in support of a course of temporary or permanent policy.

The Conditions and Causes of Comparative Public Wealth.—It is plain that wealth is not a quantity but a ratio. The wealth of mediæval Italy was great when compared with that of the decline of the Roman empire, and small when contrasted with the command possessed over the necessaries and conveniences of life by the poorest European nation at the present time. Similarly the wealth of no European state is comparable with that of England, and yet few European states possess less foreign trade and home manufacture than England possessed sixty years ago. And, again, wealth lies in the distribution, not in the appearance, of riches. One of the most coherent and long-lived delusions which has occupied the world, is the general impression of the wealth of India. Travellers and traders saw the accumulation of gold and precious stones possessed by the native princes and the wealthier classes, and concluded that the country was exceedingly rich. In fact, it is very poor, the great mass of the community subsisting on the smallest amount of the cheapest kind of grain. On the other hand, we have been continually informed by persons who have had no economical experience beyond European states, that the American government would inevitably collapse in consequence of the pressure of taxation and the drain upon the resources of the community by the enormous expenses of the war. Such critics have ignored the fact that wealth in the United States is very widely distributed, that the rate of wages and the rate of profit are very high, that the necessaries of life are abundant and cheap, and that therefore the margin of the income possessed by every one in excess of the requisite expenditure of the individual is wider perhaps than has ever been known at any other period of economical history in any state, and that therefore the means available for government expenditure were practically unlimited.

The first condition of wealth is personal freedom. There was great apparent wealth in ancient Rome; but wealth was in the hands of

a few, and the economical atmosphere was tainted with slavery. A slave-holding community never developes the mechanical arts, except to some small extent in the direction of military engines. And the reason is obvious. The most powerful cause towards the production of comparative wealth, is the impulse towards procuring the greatest possible results with the least possible expenditure of labour. But such a motive cannot be present when the mass of the community is deprived of all discretion over their labour and the fruits of their toil. Still more absolutely does a system of slavery prevent that division of labour by which labour is rendered most effective. Bad government differs from a state of slavery only in degree. The purpose of government, economically considered, is that of effecting certain services, which could not be rendered at all by individual action or voluntary combination, or could not by such action be effected so discreetly or so justly. If, however, a government transcends its functions, which are analogous to those of the division of labour, if it becomes one-sided, partial, negligent, or rapacious, if it fails to protect persons and property, and turns what activity it possesses to the interest of the ruler only and his dependents, all the evils of slavery ensue. Capital cannot be accumulated, the division of labour is prevented, the motives of production itself are ultimately destroyed, infinite moral and social evils ensue, and the community afflicted by such a scourge ultimately relapses into barbarism, and the country becomes a desert. Such is the history of the downfall of that prosperity which once characterised Asia Minor, the eastern parts of Central Asia, Egypt, and the coast of Northern Africa. Less in their effect, but similar, have been those interferences with private action which have characterised the policy of most modern governments. The trading monopolies of the time of Elizabeth and James I.; the privileges of corporate towns and guilds; taxes on occupations, restrictions upon adaptation—as are some patents; restrictions on localities or markets; taxes on articles of prime necessity with a view to furthering home production, and the whole machinery of protection and bounties; taxes on exports; hindrances put on the free circulation of capital and labour by usury laws and parochial settlements, and a host of other prohibitions and impediments, have seriously impaired, and will as long as they are persisted in seriously impair, the productive energies of those who are made subject to them.

Another condition is, that due security should be given to property. The right of enjoying and disposing of accumulations made by industry is manifestly one of the most powerful incentives to labour. No man will work unless security is given to him that he shall be able to appropriate freely the fruits of his labour; and there is nothing on which society is more sensitive and more easily alarmed than when any hindrance or limitation is put on the right of property, or any insecurity of possession threatened. But by parity of reasoning, all limitations laid by testament or grant of dead persons on the acts or powers of the living are hindrances to economical progress. They diminish the disposition towards improvement, because they diminish the fulness of the property possessed by individuals, as well as hinder alienation into the hands of those who have more capital with which to improve, and more inclination to do so.

A third condition is that the freedom of action should presume that individuals are the best judges of their own interests, and that therefore, as they ought not to be hindered, so they should not be helped. In other words, the rule of government should be in economical matters, *laissez-faire*. The reason is obvious. The inductions of the wisest government are generalities inapplicable to individuals, because circumstances are ever shifting, and therefore to be interpreted by an estimate of particular needs. Hence, primâ facie, the protection afforded to a nascent commerce by military display or force is radically bad, just as we now admit that the military defence of the colonies for the purpose of securing colonial markets was a delusion. Not indeed that the rule of *laissez-faire* is without exception. There are cases in which government is justified in interposing. An administration may tax a community in order to confer a great public benefit, as by making roads, or in order to secure large moral and material progress, as in compelling education, or to further the highest and best developements of art and science. But in these and similar cases, the defence of government interference is to be found in the facts that the voluntary association of individuals is incompetent to achieve these results, or that, the community not being yet alive to the worth of the service, and therefore exhibiting no demand, the government is justified in taking the initiative, and leaving the declaration of indemnity for such an invasion of private right to the subsequent judgment of a more enlightened and competent community.

The following appear to constitute the most powerful causes of comparative wealth: First, the division of labour. This cause of wealth was first commented on by Adam Smith, who showed that the distribution of employments induced greater dexterity in workmen, more unbroken continuity, and greater economy. This is the more manifest, when the division operates in the direction of aiding and supplementing industry by the addition of mechanical forces to human labour, or in some cases by the substitution of machinery for muscular efforts. Adam Smith, however, failed to recognise another very important result of the division of labour in cheapening the cost of production. If the whole process is done by one man, the cost of that portion of the work which needs the least skill is as great as that which needs the most, whereas by division it is possible to diminish the cost, by graduating the remuneration. And as the only limit to

the division of labour is the width of the market, it is clear that governmental regulations tending towards protection are in effect hindrances to the most powerful among the causes of comparative wealth.

Another cause is the accumulation of capital. It will be necessary to say a few words about capital and its functions, as this important term was passed over under its proper head with a very slight notice. The proceeds of labour are divided into three portions, that which is consumed for the enjoyment of the possessor, that which is employed for future production, and that which is reserved or hoarded for contingencies. In so far as the profits of labour are expended on mere enjoyment, i.e. on such gratifications as have neither directly nor indirectly any bearing on future production, the expenditure is mere consumption. The second kind of employment is, properly speaking, the function of capital; and the hoard or reserve, though not used productively, is an important resource when occasion arises. It is clear that all capital is the result of saving, i.e. it must consist of objects in demand, which are in excess of the wants or the desires of its possessor, and it is also clear, that in order to be effective, it must be consumed in some direction which shall be distinct from the immediate possessor of it. Further it must be consumed in the maintenance of labour, for the employment of capital is always with a view to profit, and profit, like every other kind of wealth, can be induced only by labour exercised upon materials and their properties. Hence the capital of a country represents all the saving which is employed in the maintenance of labour, and the increase of the capital of any country is relative to the amount which is annually accumulated over and above that which is expended in the maintenance of labour. If the expenditure were exactly tantamount to the charges incurred, so that an absolute balance were struck every year, the community would neither progress or retrograde; if it were in excess, capital would suffer diminution; if it were less, capital would accumulate. The absolute balance seems to have been almost struck in Holland at the close of the last century; the retrogression appears to have characterised Spain for the two and a half centuries following the reign of Charles V.; and the state of progress has been manifest in this country for the last 300 years, and is still more notably a feature in the growth of the United States. Capital, too, is divided into circulating capital and fixed capital. These terms are unfortunately rather ambiguous, but they are meant to distinguish those employments in which the capital changes its form and cannot be recovered in the same shape after it has discharged a single office, from those in which the same product is competent to perform a large number of operations. Thus the seed sown for a future crop is circulating capital, whereas the labour expended on the drainage of land or the building of houses is fixed. Money is a form of fixed capital, and the more thoroughly it is fixed, the larger will be the number of operations it is made to effect, or, in other words, the more will it circulate. Capital, moreover, is not, as we have seen before, money or even implements, but virtually food and necessaries for labour; i.e. money and implements are objects in which capital is fixed, and the former is a general credit, a power by which food and necessaries may be to a moral certainty attained, but it is clearly only as a purchasing power that it can be called capital; and instruments are capital embodied in a fixed form. The amount of capital possessed by a community, is the measure of the means by which the community can be stimulated to labour. Thus, as we have seen before [DEMAND], there may be an urgent call for the products of labour, but unless capital be present, in order that labour already existent may be called into activity, the demand will not be met by a corresponding supply; or, to quote Mr. Mill's adage, 'demand for commodities is not demand for labour.'

The effects of abundant capital on the progress of national wealth are, first, that it insures continuity of occupation; i.e. it enables producers to wait for the market. In countries where capital is scanty, and the mechanic or farm labourer is also the dealer, the price of commodities fluctuates largely, and yet is on the average high, because the producer has to take into account the suspension of his labour and the risks of the market. Such a state of things is inconvenient to both parties. It is an evil to the producer, because, while he is alternating between abundant employment and forced indolence, he is often obliged to suffer the loss of a forced sale. It is an inconvenience to the consumer, because he is exposed to great fluctuations in price, whereas nothing is more advantageous to both parties than the reduction of the oscillations of price to a minimum amount. Hence it is, or rather was, that when farmers occupied small holdings with scanty capital, they constantly lost all the benefit of the market from the necessity put upon them of selling in order to realise. When, however, a dealer is possessed of sufficient capital, he is able to tide over a bad time or low rates, and, by waiting for the market, to avoid loss and equalise prices. Again, the existence of abundant capital renders it possible that labour should cooperate. Great undertakings can be carried out only by large capitals, because the benefits of the division of labour, and with them of diminished cost of production, can be attained only by strictly apportioning the kind of work to be done to each labourer who can do it most cheaply.

A third cause of comparative wealth will become operative in the adjustment of the elements of production, and in the readiness with which they can circulate, i.e. be transferred to the centres in which they can be most profitably employed. These elements are labour and capital, and to these may be added,

under certain reservations, public and private credit. Labour may be in excess or defect, not, that is to say, temporarily, but permanently. When it is in excess, we have the state of overpopulation and the evils which can be remedied only by emigration on a vast scale, as in Ireland during the last twenty years. When it is in defect, there may be a great loss of capital. Such a loss occurred in the first colonisation of Western Australia, when it went under the name of the Swan River settlement. Here a vast amount of capital was exported, but in consequence of the fact that labour was deficient, and that no pains were taken by any municipal regulations to prevent the labour then present from being dispersed, the colony came utterly to ruin. At all times, indeed, labour moves more slowly than any other economical value, and therefore no legislative impediment should be put in its way. But in this country the motive energies of labour have been inconceivably crippled by the law of parochial settlement. Had it not been that the industry of the north of England always demanded more labour than was supplied, and that therefore immigration has gone on towards the manufacturing districts, unimpeded by alarms as to the contingency of pauperism, the degradation of the English labourer would have been complete. As it is, the manufacturing districts have formed a sort of half-way house to America and the colonies, and a means of relieving to some extent the excess of population. And though it will be long before the habitual helplessness of the agricultural labourer induced by the system of settlement is removed, there is reason to think that since the system is all but expunged from the statute book, labour will circulate with greater rapidity than before. [PAUPERISM.]

An excess or defect of capital may characterise the economical condition of a country. When capital is in excess, the problematical stationary state of economists is induced. We say problematical, for though there is no doubt that such a state of things marked the Dutch trade of the last century, the causes are manifestly to be found in the utter defiance of common sense which disfigured the commercial policy of Holland. In order to maintain prices, the Dutch curtailed the supply of such tropical products as were derived from their possessions. But they could not limit the competitors for a share in the profits of the business which they carried on, and they could not wholly prevent a trade carried on outside their monopoly. As a consequence, profits sank to a very low rate, so low indeed that capital could hardly be accumulated in proportion to expenditure. But when such notions are exploded, and it is understood that a low rate of profit on each sale may mean an aggregate high rate of profit by the extension of demand among consumers, it does not seem likely that such a state of things is near enough for anyone to find it worth speculating about.

Credit is not wealth, but a power by which wealth may be utilised. It is a moral force, operating in the fullest way and with the best results when it is justly accorded, by the fact that it enables the fullest use to be made of accumulations. The world will always possess borrowers and lenders. The more of both classes, the more trustworthy are the former. Again, it is impossible that all transactions, except at a great waste of power, should be simultaneously liquidated, and thus trade is impossible or scanty without mutual credit. This credit may be public or private. The credit of a government is the means by which it can negotiate loans, and depends entirely on the responsibility to which the executive is liable, and the fulness with which it is exposed to public opinion. Private credit is that of traders, and may be, indeed commonly is, far higher than that of administrations. Now as credit is measured by the rate of interest or discount, and as profit is the excess of price over the cost of production plus the rate of interest, it will be clear that deficient credit is an absolute bar to production, or at any rate to comparative profit.

A fourth cause of comparative wealth is found in the habitual standard of comfort which labourers enjoy, or, as Mr. Jones calls it, the habit of secondary wants. Demand is the stimulant to industry, other conditions being fulfilled. But demand will not be operative among the mass of the community unless they provide to themselves some standard of living from which they will not voluntarily depart. But a high standard of comfort indicates a progressive state, and a large margin of voluntary expenditure enjoyed by the working classes is at once evidence of their industrial capacity and a pledge of their procuring an increasing share in the distribution of profits. [POPULATION.]

A fifth cause lies in the spread of moral and intellectual education. The existence of a criminal population implies the subsistence of a certain class by a violent abstraction from property and profits. Not only is crime a loss proportionate to the injury inflicted, but it leads to insecurity, entails large expense in protection to persons and property, with the charges of legal procedure, and the maintenance of a large class of professional advocates. So in a less degree, but from similar causes, trades have been lost by the want of trustworthy persons, or by the frauds of producers; and the accumulation of capital is constantly checked by the want of safe objects in which the investment of profits may be made, and by the risk of peculation, embezzlement, or criminal negligence. So in common mechanical trades, overlookers are necessary in order to secure the employers of labour against fraud, and the expense of the product is enhanced by the need of watching against dishonesty. Again, the ignorance of fundamental economical laws is a serious hindrance to the productiveness of labour. The effect of imprudent marriages, of the consequent charge on the labour fund by the maintenance of the poor out of the rates, and of frequent strikes,

are illustrations of how ignorant working men are of the conditions which surround their calling in common with that of other men. At present there can be little doubt, that from one-half to one-third of the effectiveness of labour is lost by the regulations imposed out of apparent self-interest on the labour of operatives. It is certain that by far the greater part of the loss falls on themselves, in the deficiency of their habitations, and in the high rent which they pay for scanty accommodation. There can be, in short, only one legitimate way by which wages can be raised, by a diminution of labour itself, and by the search after a new market; and any indirect means by which attempts are made to raise the money rate are certainly unfair, and as certainly nugatory in the end. No one can object to any man setting a price on his labour and declining to work except at that price; but if his action under the circumstances leads him to coerce his fellow workmen, or to exact hard terms from the consumer of the commodity which he supplies, he will be sure to find that he will be among the first to suffer. Intellectual education is also a powerful cause of material progress, not only because it induces desires for a higher standard of comfort, but because it gives that capacity for adaptation and facility in invention and accommodation to circumstances, which makes labour more easily circulate, and find out its best market. The Germans, who are all subjected to primary education, are the most thriving among the American settlers.

Lastly, whatever extends the productive age of labour, is a means of increasing wealth. All the maintenance of children who die before the working age is a loss to the community, and such conditions as diminish human life when it becomes productive are of a similar character. Hence those sanitary regulations which make life longer, obviate the interruptions of sickness, and generally promote the health of the people, have a marked effect, other causes combining, on industrial prosperity. The progress which has been made in physiological enquiry, and the police precautions taken to insure health, are as powerful contributories to public wealth as any other cause. Ill-nurtured, ill-fed, ill-clothed, ill-trained labour is always dear, however nominal may be the rate at which it is remunerated.

It has not been possible in this slight sketch to give more than the leading features of a progressive state of wealth, or to do anything beyond pointing out the agencies, present and to come, which are the necessary causes of material prosperity. Some of the remaining points will be treated of in separate articles, in which it will be necessary to refer the reader to the best and most popular works on political economy. Among these, in addition to the works already named, although the writer cannot invariably agree with the conclusions arrived at, may be mentioned the useful and comprehensive manual of Mr. Henry Fawcett, the professor of political economy in the university of Cambridge; the works of Bastiat, some of which have been translated into English; and the essays edited by Dean Dawes.

Politics. Political science is that which treats of the theory and practice of government, and the subjects which it comprises have been arranged under the following heads: 1. Natural law; 2. Abstract politics, i.e. the object of a state, and the relations between it and individual citizens; 3. Political economy; 4. The science of police, or municipal regulation; 5. Practical politics, or the conduct of the immediate public affairs of a state; 6. History of politics; 7. History of the European system of states, being the only system in which the modern art of politics has received a practical development; 8. Statistics; 9. Positive law relating to state affairs, commonly called constitutional law; 10. Practical law of nations; 11. Diplomacy; 12. The technical science of politics, an acquaintance with the forms and style of public business in different countries. The ancient Greek writers treated the science of politics uniformly with reference to an imaginary perfect state, the constitution of which each philosopher propounded according to his own speculative views, and then proceeded to show in what respects existing governments differed from this ideal standard, together with the causes of these variations.

Poll. In Politics. [PARLIAMENT.]

Poll-tax (Dutch bol, *the crown of the head*). A tax levied on all members of the community, the very poorest excepted. These taxes have never been popular in this country, perhaps in consequence of the real or supposed connection of the great insurrection of the villains in 1381, with the imposition of such a levy. A poll-tax, however, had been enacted two years before the date of the insurrection, as well as in that year, the rates being graduated according to the rank and supposed wealth of the various persons assessed, and the tax being therefore fair in its incidence.

The hearth-money of the reign of William III. was virtually a poll-tax, and similarly unpopular; and in some of the states composing the American Union, a small tax of this kind is regularly imposed on all alike, as, for instance, a dollar on each adult in Massachusetts.

Pollard. A tree with the head, or poll, cut off at the height of ten or twelve feet from the ground, for the purpose of inducing it to throw out branches all round the section where amputation has taken place. The branches so thrown out are cut off periodically, when they attain the length of eight or ten feet, to be used as fuel, fence wood, or for other rustic purposes. Pollard trees are for the most part found in hedgerows, which they greatly injure by the dense shade produced by their branches on the plants below; and excepting when the round formal heads of the pollards enter into combination with overgrown hedge plants, or with large trees which have not been pollarded, they disfigure the landscape, from the monotony and meanness of their appearance as compared

with that of trees undecapitated and left in their native luxuriance. In the time of Evelyn the term *pollard* appears to have been applied chiefly to trees which were lopped or deprived of their side branches, excepting a few at top, leaving the tree standing like a naked pole. Examples of this kind of pollard are frequent among the hedgerow elms in the neighbourhood of London and in Devonshire. The decapitated tree, now called a *pollard*, was in Evelyn's time called a *dottard*.

Pollen (Lat. *fine flour*). In Botany, the pulverulent substance which fills the cells of the anthers of a plant, consisting of a multitude of hollow cases, of extreme minuteness, filled with a fluid holding very fine molecular matter in suspension. The latter is eventually discharged by the grains of pollen through their hollow tubes, and is supposed to be the spermatic fluid of a plant.

Pollen Tubes. The tubular processes emitted by the pollen when it comes in contact with the stigma of a plant, and which are supposed to conduct the impregnating matter down the style into the ovules through the foramen.

Pollux (Lat.). In Astronomy, one of the twins forming the constellation *Gemini*. [Castor.] Pollux is also the name of a star of the second magnitude in the same constellation.

Pollux. In Mineralogy, a rare mineral. A hydrated silicate of alumina, potash, and soda, remarkable for containing 34 per cent. of cæsium, according to recent analyses of M. F. Pisani. It is massive, colourless, and transparent, and like quartz in appearance. It is found in the granite of Elba associated with Castor.

Pollux. In Mythology. [Polydeukes.]

Polyadelphous (Gr. πολύς, and ἀδελφός, *a brother*). In Botany, this term is applied to flowers which have the stamens united into several distinct sets.

Polyandria (Gr. πολύς, and ἀνήρ, *a man*). The thirteenth class in the Linnæan system. It includes those plants the flowers of which have hypogynous stamens more than twenty in number.

Polyanthes (Gr. πολυανθής, *many-flowered*). A favourite cultivated flower, quite distinct from the Polyanthus. The genus *Polyanthes* belongs to the *Liliaceæ*, and its most familiar species is the Tuberose met with in our hothouses, and prized on account of the fragrance of its flowers. It is a perennial, with bulbtuberous stems, throwing up from the heart of leaves a tall flowering scape, which supports at top a short many-flowered spike of creamy-white highly fragrant flowers, the double forms of which are greatly prized. Large quantities are annually imported from Italy. It is recorded that in sultry evenings, after thunder, when the atmosphere was highly charged with electric fluid, the Tuberose has been observed to dart small sparks of lucid flame from such of its flowers as were fading.

Polyanthus (Gr. πολυανθής). An umbellate-flowered variety of the Primrose, *Primula vulgaris*, cultivated in gardens for its variously coloured gay-looking flowers.

Polyarchy (Gr. πολυαρχία). A word sometimes used by political writers in a sense opposed to monarchy: the government of many, whether a privileged class (aristocracy) or the people at large (democracy).

Polyargite. An altered form of Anorthite from Sweden.

Polybasite (Gr. πολύς, *many*, and βάσις, *base*). A sulphantimonite of silver, in which part of the silver is replaced by copper, and part of the antimony by arsenic. It occurs in short, tabular, six-sided prisms, which are striated parallel to their bases, opaque, and of an iron-black colour by reflected light, but cherry-red in thin slices when viewed by transmitted light. It is found in the mines of Durango in Mexico, Freiberg in Saxony, Schemnitz in Hungary, and Przibram in Bohemia. It has its name from the large quantity of silver present, compared with the other sulphides of that metal.

Polychrest (Gr. πολύχρηστος). A term applied by the old chemists to certain preparations which they regarded as possessed of multifarious virtues. *Polychrest salt* was the sulphate of potash.

Polychroilite (Gr. πολύς, *many*, χροιά, *colour*, and λίθος, *stone*). A silicate of alumina, with peroxide of iron and magnesia, from Krageröe in Norway.

Polychroite (Gr. πολύς, and χροιά, *colour*). A term applied to the colouring matter of saffron, from the variety of colours which it exhibits when acted upon by various re-agents.

Polychromatic Acid (Gr. πολυχρώματος, *many coloured*). A compound resulting from the action of nitric acid upon aloes. When used as a dye-stuff it yields a variety of colours.

Polychromy (Gr. πολύχρωμος, *many-coloured*). In Architecture and Sculpture, the art of decorating with many colours. It is now generally understood that the Greeks habitually coloured their architecture, the exterior of buildings as well as the interior; but that they also coloured their sculpture is not so generally admitted. That the practice, however, of colouring their statues was established among the Greeks of the most refined period, is quite certain. It is proved by passages in Plato, Pausanias, Lucian, Plutarch and other writers. Marble statues were coloured in encaustic, and statue painting was a distinct profession. The naked flesh itself was not commonly painted, but was stained with an encaustic varnish; the colouring was apparently generally confined to the hair, eyes, lips, the drapery, and the ornaments in general; sometimes the hair was gilded, and the eyes were not unfrequently of glass, with eyelashes of copper gilt. The celebrated Nicias was an ἀγαλμάτων ἐγκαυστής, or statue painter, in his youth: he coloured some of the statues of Praxiteles. It is to this practice that Pliny refers when he speaks of the *circumlitio* of Nicias as applied to the statues of Praxiteles.

(Wornum, *Epochs of Painting &c.* p. 103 ff.) The acrolithic and CHRYSELEPHANTINE sculpture was virtually polychromic. (Kugler, *Ueber die Polychromie &c.*; Semper, *Ueber bemalte Architectur und Plastik bei den Alten*; and Quatremère de Quincy, *Le Jupiter Olympien.*)

Polycotyledonous (Gr. πολύς, and κοτυληδών, *a seed lobe*). In Botany, this term is applied to those embryos which have more than two cotyledons.

Polycrase (Gr. πολύς, and κρᾶσις, *mixture*). A rare mineral occurring at Hitteroe in Norway, in black six-sided tables, which are of a brownish colour in thin splinters. It contains titanic and columbic acids, zirconia, yttria, peroxide of iron, protoxide of uranium, protoxide of cerium, a small quantity of alumina and traces of lime and magnesia. The name has reference to the many substances which enter into its composition.

Polydectes. [PERSEUS.]

Polydegmon (Gr. πολυδέγμων, *receiving many*). In Greek Mythology, a name given to Hades. [PERSEPHONÊ.] Another form of the name is Polydectes, the persecutor of Danaê and of her son PERSEUS.

Polydeukes (Gr. Πολυδεύκης). In Mythology, one of the Dioscuri (Διόσκουροι, *sons of Zeus*), the other being Castor. Of the birth and home of these heroes the legends give very contradictory accounts. In the *Odyssey* (xi. 298) they are sons of Tyndareus and Leda, and therefore brothers of Helen. [PARIS.] According to another tale, they with their sister were all children of Zeus, and sprang from the same egg. Another myth calls Polydeukes and Helen only the children of Zeus, and makes Polydeukes immortal, Castor, as son of Tyndareus, being subject to age and death like other mortals. The second part of the name Polydeukes is found in DEUCALION, and is probably another form of λευκός, *light*, or *brilliant*. The Dioscuri take part in the expedition of the Argonauts [MEDEA; MYSTERIES]; but according to the *Iliad* they had died or disappeared from the earth before the Trojan war. The name of Castor was associated especially with skill in the taming and management of horses, that of Pollux, with boxing. In the *Odyssey* (xi. 301) they are represented as coming to life on alternate days and enjoying an honour equal to that of the gods. [NEMESIS.]

Polydipsia (Gr. πολύς, *much*, and δίψα, *thirst*). Excessive thirst. This name has been given to a form of diabetes known as *diabetes insipidus.* It is characterised by the discharge of large quantities of urine of low specific gravity, and is a most dangerous malady. Pathologists incline to regard it as the result of nervous lesion.

Polygala (Gr. πολύς, and γάλα, *milk*). The typical genus of *Polygalaceæ*, very widely distributed and exceedingly various in character. A few species, as *P. cordifolia* and its allies, are handsome greenhouse shrubs. The most important, however, is *P. Senega*, the root of which is used as a stimulant diaphoretic and expectorant, especially in cases of chronic bronchitis. The active properties appear to depend upon an acid substance found principally in the rind of the root, and called *polygalic* acid, or sometimes *senegin*. This root was introduced into medical practice by Dr. Tennant, a Scotch physician residing in Pennsylvania, as a remedy for snake-bites. Several other species are described as having similar virtues. They seem to act as stimulant emetics, purgatives, and diaphoretics, and relieve the embarrassed breathing which occurs in such cases.

Polygalaceæ (Polygala, one of the genera). A natural order of irregular polypetalous Exogens of the Sapindal alliance, possessing tonic, astringent, and nephritic properties. The order is known by its complete irregular unsymmetrical flowers, its naked petals, its one-celled anthers opening by pores, and its carunculate seeds. The species are also sometimes cultivated for the sake of their beautiful flowers. They usually inhabit temperate climates, and are common at the Cape of Good Hope. Rhatany root, a powerful astringent, belongs to *Krameria*, a genus of this order.

Polygamous. In Botany, among grasses this term signifies that when one of the two flowers of which a spikelet consists is unisexual, the other is hermaphrodite, as in *Spodiopogon*, &c. Among other plants it expresses the presence in the same individual of male, female, and hermaphrodite flowers.

Polygamy (Gr. πολυγαμία, from γάμος, *marriage*). The custom of having several wives; a custom apparently common to all nations in remote antiquity, and common now to most of those in which the tie of marriage is recognised, and to which Christianity has not extended. It was admitted under the Mosaic dispensation (Exod. xxi. 10; Deut. xxi. 15); and Selden (*Uxor Hebraica*) has shown its prevalence among the Jews, without mentioning the extraordinary instances of sovereigns, such as David and Solomon. Some have supposed, from such passages as 1 Tim. iii. 2, that it was occasionally practised down to the apostolic age. The severer manners of Western nations seem to have repudiated it. The notion that the Athenian laws allowed of two wives (founded in part on a passage in *Athenæus*, xiii. i.) seems a mistake; but it appears to have been allowed to a citizen, in addition to his lawful wife, herself a citizen, to live in a kind of legitimate concubinage with a female not belonging to that class. Thus, if there is any truth in the story of the two wives of Socrates, his plague, Xanthippe, was the wife by right, while the softer Myrto was a wife only by courtesy. In republican Rome no such license was known; but under the emperors the practice of polygamy seems to have crept in from the East, though repudiated both by the moral sense and civil usages of the people. Valentinian I. legalised it by an edict. But the Christian ecclesiastics of the empire strenuously opposed it; and it gradually disappeared from Christendom after the

fall of the Roman empire. In the East it has continued to prevail. A few bold writers in modern times have raised the defence of polygamy, grounded on an alleged absence of express prohibition. Bernardus Ochinus, a well-known and able but unsteady theologian of the sixteenth century, who belonged by turns to the Roman Catholic and Protestant communions, is among the most remarkable. Lyserus (*Polygamia Triumphatrix*) adopted a still more decided view. The Rev. Mr. Madan, in his *Thelyphthora* (a work which excited extraordinary and very unfavourable sensation on its appearance), asserted that the injunctions in the Epistles to Timothy and Titus, restraining bishops and elders from having more than one wife, meaning one wife at a time, plainly demonstrated the lawfulness of the practice in all others. But a greater number of philosophical writers have sought for a justification of the practice in the East. Voltaire, Montesquieu, and others, defend it on the ground of the rapid decay of female beauty in those regions. Montesquieu also relies on the strange notion, that the number of females in Eastern countries is much greater than that of males. But the supposed fact on which these reasonings rest seems to be altogether imaginary. At all events, the *practice* of polygamy in the East is confined to so few that it can have little direct effect on manners, and none on population. Niebuhr says, that in Arabia the conduct of those who take more than one wife 'is blamed by all other men.' But it seems scarcely to have occurred to most reasoners that while polygamy itself is rare, its recognition is almost always accompanied with the toleration of concubinage by public morality. The man who is not rich enough to take two wives, or who does not choose to encounter the household disturbances which follow such an arrangement, falls entirely in with the public opinion of his class, in taking into his family a recognised concubine to dwell with his lawful spouse. Some curious remarks on the subject of polygamy may be found in Lady Duff Gordon's *Letters from Egypt*, and in the writings of Captain Burton, *Journey to the Great Salt Lake City*, &c. [MORMONISM.]

Polygastria (Gr. πολύς, and γαστήρ, *a stomach*). The name of the most minute and simple class of Infusories and of the whole organic kingdom. The Polygastrians have been characterised as animalcules devoid of spinal marrow, and of vascular and respiratory organs, with many stomachs, of an indefinite form, and androgynous, with spurious locomotive organs of various nature. They are all endowed with an organisation characteristic of the kingdom *Acrita*; and manifest such modifications of internal structure and external form that they could be divided into twenty-two families, of which eleven are naked and eleven clothed in a silicious case. They occur in all parts of the world, and differ according to diversity of climate, region, kind of water, &c. They are invisible to the naked eye; but, by their immense numbers, they can impart a distinct colour to the water in which they swarm, and are one of the causes of the phosphorescence of the sea. They enjoy the most extensive powers of reproduction; and through their faculty of spontaneous *fission*, the individual becomes constant, and, as it were, perpetually renews its youth. By virtue of the imperishability of their external cases the *Polygastria* have formed vast masses of rock, as at Bilin in Bohemia, where a single stratum, extending over a wide area, is no less than fourteen feet thick; and this consists exclusively of the cases of *Bacillaria*, *Gaillonella*, &c., united together without any visible cement. They sometimes so choke up water by their vast numbers as to cause the death of fishes contained therein. They appear never to sleep: they are very tenacious of life, and fall into a kind of torpidity by excess of dryness, heat, or cold. The more minute species are probably often suspended in the air. They act according to external circumstances, seemingly as the higher organised animals do. They are injuriously affected or killed by strong poisons, but can sometimes support great degrees of warmth and cold, and can live with or without light. Their motions are slow. Ehrenberg calculates that the *Monas punctum*, if it were to continue its ordinary rate of motion in a straight line, would traverse one mile of space in five years; while the *Navicula grandis* would require forty years to travel over the same distance. Their movements simulate the phenomena of consciousness and choice, and muscular power is significantly indicated by the strong maxillary apparatus with which many are provided.

Polyglot (Gr. πολύγλωττος, *many-tongued*). A word generally applied to such Bibles as have been printed with the text in various languages. The most ancient instance of this parallel representation of various texts is the work of Origen, known by the name of the *Hexapla*, in imitation of which several similar editions of the Scriptures have been published since the invention of printing. Of these the most important are: 1. *The Complutensian*, or edition of Cardinal Ximenes, printed at Alcalá in Spain, 1515, in four languages, comprehended in six vols. folio. 2. *The Plantin*, Antwerp 1572. 3. *The Polyglot* of De Sacy, Paris 1645. 4. *The English* or Walton's *Polyglot*, London 1657. These contain among them the Hebrew, Chaldee, Syriac, and Samaritan texts, with Latin versions of each; the Septuagint, the Greek of the New Testament, the Italic and the Vulgate; with some of the Hebrew and Chaldee paraphrases, and copious indexes and grammatical illustrations. 5. Hutter's *Polyglot*, Nuremberg 1599, contains twelve languages; the Hebrew, Syriac, Greek, Latin, German, Bohemian, Italian, Spanish, French, English, Danish, and Polish. (Hallam, *Literary History*, iii. 446.)

Polygon (Gr. πολύγωνος). A figure of many angles or corners. In *polygonometry*,

that branch of geometry in which the properties of polygons are investigated, the angular points are conceived to be situated either anywhere in space, when the polygon is termed *skew*; or on the surface of a sphere, when it is termed *spherical*; or in a given plane, which is the most frequently occurring case, and the only one we shall here notice.

The *complete polygon* of n angles has

$$\frac{n(n-1)}{1.2}$$

sides, which are the right lines joining all possible pairs of points. Thus, although a complete *trigon* has only three sides, a complete *tetragon* has six, and so on. [QUADRANGLE.] A complete n-gon comprises $3.4 \ldots (n-1)$ different *simple polygons*, each of which is formed by joining the n points in a *certain order*. Of such simple polygons, however, only those are contemplated in elementary geometry whose unproduced sides do not cut each other, and the latter are themselves divided into two classes; viz. *convex polygons*, the interior angles of which are all less than two right angles, and *concave polygons*, of which one (or more) of the interior angles exceeds two right angles. The angles of the first class are all *salient*, whilst polygons of the second class are distinguished by the possession of one or more *re-entering* angles. Although Euclid considers only convex polygons, the first corollary to his prop. 32, book i. (according to which all the interior angles, together with four right angles, are equal to twice as many right angles as the figure has sides), is also true for concave polygons. His second corollary, however, according to which the sum of all the exterior angles is equal to four right angles, is only true in the case of convex polygons.

Theoretically the simplest way of finding the area of an ordinary polygon is to take the sum of the areas of the triangles into which it may always be divided. Other elegant methods have been given by Gauss, in Schumacher's translation of Carnot's *Géométrie de Position* (Altona 1810), and by L'Huilier, in his *Polygonométrie* (Geneva 1789).

A polygon whose angles and sides are all equal, is termed *regular*. The corners, as well as the sides, of such a polygon are equidistant from one and the same point, the common centre of the inscribed and circumscribed circles. The problem, to inscribe a regular polygon in a circle by means of the ruler and compass alone, is not always solvable. Euclid has shown how to inscribe a regular trigon, tetragon, pentagon, and quindecagon in a circle, and by repeated bisection of sides, his solutions may easily be extended to polygons having 2^m, 3.2^m, 5.2^m or 15.2^m angles, where m is any number whatever. Gauss has shown, too, in his *Disquisitiones Arithmeticæ*, that we may consider as inscriptible all polygons the number of whose sides is equal to the product of some power of 2 by a prime of the form 2^m+1. The first two primes of this form are 3 and 5, corresponding to the values 1 and 2 of m. The value $m=3$ gives the number 9, which is not a prime; to $m=4$ corresponds the prime 17; and the next prime of the series is 257, corresponding to $m=8$. The inscription of the 257-gon has been examined by Richelot in Crelle's *Journal*, vol. ix.; that of the 17-gon has been treated by Gegenbret, in his *Élèments de Trigonométrie*; by Grünert, in Klügel's *Math. Wörterbuch*; by Staudt in Crelle's *Journal*, vol. xxiv.; by Mr. Lowry in Leybourn's *Math. Repository*, vol. iv.; as well as by several others.

Besides the ordinary regular polygons, there are also regular stellated polygons which are formed by drawing, without lifting the pen, diagonals of an ordinary polygon so as always to cut off the same number of sides, the number cut off being prime to the total number. For instance, 1 2 3 4 5 1 being a regular pentagon, 1 3 5 2 4 1 will be a stellated one.

Little need be added with respect to spherical polygons. The area of a convex spherical n-gon is

$$[\Sigma-(n-2)\pi]r^2$$

if Σ denote the sum of its angles and r the radius of the sphere.

POLYGON. In Fortification, a polygon is either *exterior* or *interior*. The exterior polygon is the figure formed by lines connecting the angles of the bastions with one another all round the work; the interior polygon by lines in prolongation of the curtains. [FORTIFICATION.]

Polygon of Forces. In Mechanics, the name given to a theorem, the discovery of which is attributed to Leibnitz. The theorem is this: If any number of forces act upon a point, and a polygon be taken, one of the sides of which is formed by the line representing one of the forces, and the following sides in succession by lines representing the other forces in magnitude, and parallel to their directions, then the line which completes the polygon will represent the resultant of all the forces.

Polygonaceæ (Polygonum, one of the genera). A natural order of herbaceous, rarely shrubby, apetalous hypogynous Exogens, inhabiting the whole world, and referred by Lindley to the Silenal alliance. They are distinguished from most other plants by the cohesion of the scarious stipules into a sheath, technically called an *ocrea* or *boot*, and by their triangular fruit. Sorrel on the one hand, and Rhubarb on the other, represent the general qualities of this order. While the leaves and young shoots are acid and agreeable, the roots are universally nauseous and purgative. *Rumex acetosa* contains pure oxalic acid, and many species of *Polygonum* are used in dyeing. The *Rheum* or Rhubarb, and *Rumex* or Dock, are well-known plants of this order; which is also sometimes remarkably astringent, as in the case of the *Cocoloba uvifera*, or Sea-side Grape of the West Indies, an extract of whose bark forms a kind of KINO.

Polygonal Numbers. In Arithmetic, the successive sums of the terms of an arithmetical

series beginning with unity. They are FIGURATE NUMBERS of the second order.

A very general and remarkable property of polygonal numbers was discovered by Fermat, though it has yet been demonstrated only in respect of the triangular and square numbers. It is this: Every number whatever is the sum of one, two, or three triangular numbers; the sum of one, two, three, or four squares; the sum of one, two, three, four, or five pentagonal numbers; and so on.

Polygram (Gr. πολύς, and γράμμα, *a line*). A figure consisting of many lines or sides. An ordinary polygram is the same as an ordinary POLYGON [which see]. It would be well, however, if the distinction between polygon and polygram were more strictly adhered too. A complete n-gram has $\frac{n(n-1)}{1.2}$ angular points or corners, whilst a complete n-gon has $\frac{n(n-1)}{1.2}$ sides. As an illustration, see QUADRANGLE and QUADRILATERAL.

Polygraph (Gr. πολύς, and γράφω, *I write*). In Bibliography, this term designates a collection of different works either by one or several authors.

Polyhalite (Gr. πολύς, and ἅλς, *salt*). A hydrous sulphate of lime, potash, and magnesia, with muriate of soda, found at Ischl, in Upper Austria, where it occurs in compact fibrous masses of a brick-red or flesh colour, and sometimes colourless.

Polyhedron (Gr. πολύς; ἕδρα, *a base*). In Geometry, a solid bounded by many planes or *faces*. Each face is bounded by three or more right lines or *edges*, and three or more faces by their intersection form a *corner*. The theory of polyhedrons, although studied by the ancients, is still incomplete and defective in many points; we shall merely mention a few of their most elementary and important properties.

If with respect to any sphere, we take the polar plane of every corner of a given polyhedron, we shall obtain a second having as many faces as the first has corners, as many corners as it has faces, and precisely the same number of edges. [POLES AND POLARS.] So that the *principle of duality* holds for all polyhedrons; that is to say, to every polyhedron corresponds its *conjugate*, which has as many n-angled faces as the first has n-angled corners.

If by taking away one face from an *incomplete* or *unclosed* polyhedron which has e edges, c corners, and f faces, we remove n corners, we shall necessarily diminish the number of edges by $n+1$, so that the number $c+f-e$ will remain unaltered by the operation, and consequently also by its repetition. Since this repeated subtraction, however, must ultimately lead to a single face with as many corners as edges, we see that for every unclosed polyhedron $c+f-e=1$. If we unclose any polyhedron, therefore, of E edges, C corners, and F faces, by removing a face, we shall obviously have $C+(F-1)-E=1$; i.e. $C+F=E+2$. This fundamental theorem, according to which *the number of corners, together with the number of faces, of every ordinary polyhedron, exceeds by two the number of its edges*, although known to Descartes, was rediscovered and first published by Euler in the *Nov. Comm. Petrop.* 1752. From it numerous consequences may be deduced. It can be shown, for instance, that there is no polyhedron of seven edges, and that some of the faces of every polyhedron must necessarily be either triangular, quadrangular, or pentagonal; hence also some of its corners must necessarily be triangular, quadrangular, or pentagonal. These are consequently termed the *essential* elements of every polyhedron. It can be shown, too, that there are but five distinct *regular polyhedrons*, or such as have equal regular polygonal faces and corners. In fact, if each face is a regular polygon of n sides, then obviously $2E=nF=mC$, if m be the number of plane angles that meet at every corner. It follows, therefore, from the fundamental relation, that

$$E=\frac{2mn}{2m+2n-mn}.$$

This can only be a whole number in five distinct cases, since neither m nor n can be less than three or greater than five. The name and nature of each of the *five regular polyhedrons*, or, as they are often called, *Platonic bodies*, is given in the following table.

Name	m	n	E	F	C
Tetrahedron or Regular Pyramid	3	3	6	4	4
Hexahedron or Cube	3	4	12	6	8
Octahedron	4	3	12	8	6
Dodecahedron	3	5	30	12	20
Icosahedron	5	3	30	20	12

The hexahedron and octahedron are conjugate, as are also the dodecahedron and the icosahedron. The tetrahedron is manifestly its own conjugate.

Besides the above, there are the *semi-regular polyhedrons* of Archimedes, the corners of which are equal and similar to one another, but formed by regular polygons of different kinds. Pappus (in the fifth book of his *Collections*) and Kepler enumerate thirteen distinct semi-regular polyhedrons. They omit two, however: one is a right prism, whose bases are equal regular polygons of any number of sides, and whose lateral faces are all squares; the other may be formed from the first by conceiving one of the two equal polygons to be first twisted, and each of its corners then joined to two of the other polygons, so that the lateral faces become equilateral triangles.

There are also *stellated regular polyhedrons*. These were first described by Kepler, and have been since studied by Poinsot and others. (*Journal de l'École Polytechnique* 1809, and *Comptes Rendus* 1858–9.) We may mention, lastly, that the theory of polyhedrons has been greatly extended in recent years by the researches of Kirkman, whose memoirs will be found in the *Phil. Trans. of the Royal Society*.

Polyhedron. In Optics. [Polyscope.]

Polyhydrite (Gr. πολύς, and ὕδωρ, *water*). A hydrated silicate of iron from Breitenbrun in Saxony. It is the same as the Hisingerite of Berzelius.

Polyhymnia (Gr. Πολυΰμνια). The muse who presided over lyric poetry. (Hesiod. *Theog.* 78; Hor. *Od.* i. 1.)

Polykrase (Gr. πολύς, and κρᾶσις, *combination*). A rare mineral occurring in black six-sided tables: it contains titanic and tantalic acids, zirconia, yttria, alumina, magnesia, lime, and the oxides of iron, cerium, and uranium. It is found at Hitteröe, in Norway.

Polylite (Gr. πολύς, and λίθος, *stone*). A variety of Pyroxene from Hoboken in New Jersey. The name has reference to the numerous constituents of which it is composed.

Polymignite (Gr. πολύς, and μίγνυμι, *to mix*; from the number of its components). A titanate of Zirconia, which occurs in long thin prismatic crystals with a brilliant submetallic lustre, in the zircon-syenite of Fredericksvärn in Norway.

Polynomial. [Multinomial.]

Polynomial Theorem. [Multinomial Theorem.]

Polyonymy (Gr. πολυωνυμία, *a multitude of names*). The description of the same object under several names. This practice marks one of the necessary stages in the growth of language, and furnishes the great source of Mythology. It is obvious that a common root may be used to describe different objects which agree in some special point: thus, a word denoting brightness might be applied to the morning, a fountain, or the spring-time of the year, which would thus be *homonymous*, or namesakes. But it is also manifest that the same object may be described by several characteristics. The sun may be called the child of the night, the destroyer of darkness [Perseus], the slayer of the dawn [Apollo], the husband of the morning [Eos], or of the dew [Procris]; and thus the sun would be *polyonymous* or many-named, while each name would supply the idea of a separate myth. (Max Müller, *Lectures on Language*, second series, viii.)

Polyoptron. In Optics, a glass through which objects appear multiplied, but diminished. It consists of a lens, one side of which is plane, while in the other are ground several spherical concavities. Each of these concavities becomes a plano-concave lens, through which an object appears diminished; and when there are a number of them together, the object will be seen through each, and thus multiplied.

Polypes (Gr. πολύπους). The name of an extensive group of radiated animals in the system of Cuvier, associated together by the common character of a fleshy body, of a conical or cylindrical form, commonly fixed by one extremity, and with the mouth situated at the opposite end and surrounded by more or less numerous arms or tentacles. Under this external form are masked various grades of organisation, of which three at least have been well defined by recent and minute anatomical researches.

The lowest grade of organisation is manifested by the fresh-water Polype (*Hydra*), and the compound marine corallines (*Sertulariæ*, *Tubulariæ*, &c.). The body here consists of a granular parenchyma, having a contractile power in every part, not requiring a distinct allocation and arrangement of muscular fibres. When it is defended, as in the Corallines, by a polypary, it can be retracted into its cell without being folded upon itself. The oral tentacles are not provided with vibratile cilia; the stomach is not distinct from the parietes of the body. The polypes thus organised have been termed *Dimorphæ* by Ehrenberg; *Hydrozoa* by Owen; and *Nudibrachiata*, or Hydriform Polypes, by A. Farre. In the second group of Polypes the body is distinctly membranous and fibrous, and the stomach forms a separate pouch suspended in its centre. The stomach has but one external orifice, which serves for mouth and vent; but posteriorly it communicates with the main cavity of the body. This is divided into several compartments by vertical partitions passing from the walls of the cavity to those of the stomach; and with the chambers thus formed the tubular arms surrounding the mouth communicate: these arms are not ciliated externally. This group of Polypes has been termed *Anthozoa* by Ehrenberg: it includes the Sea-anemones, Madrepores, Coral-polypes, &c. In the third and highest group of Polypes the parietes of the stomach are not only distinct from those of the body, but are continued into an intestinal tube, which is reflected forward and terminates in a distinct anal aperture near the mouth: the tentacula are provided with vibratile cilia. The Polypes of this division are aggregated or compound, and provided with flexible or calcareous cells: they have been termed *Bryozoa* by Ehrenberg, and *Ciliobrachiata* by Farre. All the groups of Polypes propagate by gemmation, and likewise by ova, which are first developed into ciliated and locomotive gemmules. In some *Ciliobrachiata* the sexes are distinct. The *Acalephæ* of Cuvier belong, metagenetically, to the *Hydrozoa*, while the *Bryozoa* have affinity with the compound *Ascidians*.

Polypetalous (Gr. πολύς, and πέταλον, *a leaf*). In Botany, a term applied to flowers in which the petals are separate, rather than to those in which they are numerous, as the name would seem to imply. It is used as the antithesis to *monopetalous*.

Polyphemus. In Mythology. [Cyclopes.]

Polypodiaceæ (Polypodium, one of the genera). The most comprehensive of the natural orders under which Ferns are arranged, including nearly all the species which are known. It is distinguished mainly by the presence in the spore-cases of an elastic jointed ring which nearly surrounds them, and by the contraction of which they seem to burst open when ripe. [Filices.]

Polyporus (Gr. πολύπορος, *with many pores*). A very extensive genus of Fungi, belonging to the pore-bearing division of that vast order. The pores vary much in size, being sometimes almost invisible to the naked eye. Some of the species are of a brilliant scarlet, others lilac, yellow, orange, &c., but the predominant colours are tints of brown. A few of the species, as *P. ovinus*, afford a grateful food, but in general they are coarse, tough, and indigestible. *P. tuberaster*, which springs from the Fungus Stone [Pietra Fungaja], is esteemed in Italy, and a species is raised from pollard hazels by roasting them gently before the fire and then keeping them properly irrigated. *P. fomentarius* supplies the best Amadou of commerce, though inferior kinds are produced from other species, as *P. igniarius*. *P. officinalis* was once a celebrated drug, but it is now little used, though still to be obtained in the herb-shops; it grows almost exclusively on Larch. *P. destructor* and some others are the pest of wooden structures, while the spawn of *P. hybridus* is the dry-rot fungus of oak-built ships. *P. betulinus* forms excellent razor-strops.

Polyptychodon (Gr. πολύς; πτυχή, *a fold*; and ὀδούς, *tooth*). A genus of Sauropterygian reptiles (equalling *Pliosaurus* in size), in which the teeth have a strong conical crown with a subcircular transverse section, the longitudinal ridges of the enamel being set close all round the crown, whence the name of the genus; such teeth may be distinguished from the teeth of *Mosasaurus* or *Pliosaurus* by the absence of the smooth, almost flattened faces of the crown, which surface, in those genera, is divided by two longitudinal ridges from the rest of the crown. The teeth are implanted in distinct sockets, as in *Plesiosaurus*.

Polypus (Gr. πολύπους, *many-footed*). In Surgery, a fleshy tumour, which is occasionally formed in the nostrils: the same term is also applied to a fleshy tumour of the uterus.

Polysarkia (Gr. πολυσαρκία). Corpulency. [Obesity.]

Polyscope (Gr. πολύσκοπος, from σκοπέω, *I look*). In Optics, a lens plane on one side and convex on the other; the convex side being formed of several plane surfaces, or *facettes*, so that an object seen through it appears multiplied. The reason of the multiplication of the image is this: When the opposite sides of a thick piece of glass are not parallel, an object seen through it appears out of its true place on account of the refraction; consequently, if a lens is ground so that portions of its convex surface are differently inclined to its plane side, the object will appear in different places at the same time. The polyscope may be used to collect the images of several dispersed objects into a single point, or to collect parts of the same object represented in different places, so as to form a single image. The instrument is a mere toy, and used only for the purpose of amusement.

Polyspaston (Gr. πολύσπαστος, *drawn by many cords*). A term used by some of the old writers on Mechanics to denote an assemblage of pulleys for raising heavy weights.

Polysphaerite (Gr. πολύς, and σφαῖρα, *a sphere*; from its occurrence in roundish masses). A variety of Brown Lead-ore [Pyromorphite] containing phosphate of lime, and a certain quantity of fluoride of calcium. It is of a brown or yellow colour, slightly darker than Pyromorphite, and has a radiated structure internally. It is found near Freiburg in Saxony.

Polystyle (Gr. πολύστυλος, *many-columned*). In Architecture, an edifice in which there are a great number of columns.

Polytechnic School (Gr. πολύτεχνος, from πολύς, and τέχνη, *art*). This establishment was founded in 1794, at Paris, by a decree of the National Convention. Its object is to instruct youth in the mathematical, physical, and chemical sciences. Napoleon, who introduced various modifications into its constitution, gave a military turn to its discipline. It prepares pupils for the artillery service, and civil and military engineering. The number of students is about 350. Youths selected by competitive examination are admitted between the age of sixteen and twenty, or, if in the army, twenty-five, and the course of study lasts two years. It is now regulated by a series of laws passed from 1852 to 1856. In the lists of its professors have been included the illustrious names of Lagrange, La Place, Monge, Berthollet, &c.; and from the ranks of its pupils have proceeded, almost without exception, all the mathematicians and philosophers of France who have attained to eminence during the last half-century.

Polytelite (Gr. πολυτελής, *valuable*). A name for the varieties of Grey Copper-ore which contain silver and quicksilver.

Polythalamaceans (Gr. πολύς, and θάλαμος, *a chamber*). A name applied by De Blainville to an order of Cephalopods, including those which have many-chambered shells. Like all divisions founded merely on external or dermal characters, it contains animals of different degrees of organisation, which cannot be grouped together in the same order in a natural system. Thus *Spirula* and *Belemnites*, for example, are joined with *Ammonites* and *Nautilus*. [Tetrabranchiates.]

Polytheism (Gr. πολύς, and θεός). A belief in many gods, in contradistinction to Monotheism, or the belief in one God. In the absence of historical documents, the evidence of language alone can furnish grounds for definite conclusions on the origin and growth of polytheism. That evidence shows that human thought had already passed through several stages, before the idea of God was embraced by the mind [Language]; but other influences were simultaneously at work, which could not fail to modify that idea. Ignorant of the nature of his own life, and knowing nothing of the nature, origin, and properties of other objects, man could only attribute vaguely to all visible things the same kind of existence as that which belonged to himself. This existence involved

simply the notion of consciousness, for the distinction between consciousness and personality was of later growth. Thus the sun, moon, and stars, would all be living beings; and their influence, in the lack of any idea of a natural order, would be seen in the working of the material world, and in all the accidents of human life. Their action would appear either beneficent or malign; and hence these beings would be invested each with their special character. As being beyond human control, and as affecting the condition of men, they would be loved or feared; and with the growth of the idea that they might be propitiated or appeased, the system of polytheism would be complete. But as long as the names applied to the sun or other objects were understood in their original sense as names for those objects, the number of the deities would be but small. When, as a consequence of dispersion, the meaning of these names was either in part or wholly forgotten, all the words which had described some visible object became a name for an independent being. [POLYONYMY.] The sun as the destroyer of night became PERSEUS; as the lord of light, Phœbus; as the king of day, Kephalos (Cephalus); as sinking to sleep, ENDYMION. The same process went on with all other names, and the result was an infinite multiplication of mythical beings; or, as objects of worship, gods. This developement may be distinctly traced in the fundamental Brahmanic and Zoroastrian myths. In the former, Indra is the sun-god who fights with and conquers his adversary VRITRA, the dark power of night; but the introduction of an ethical sentiment is manifest even in Vedic hymns which speak of Vritra as the enemy of man. On the Iranian soil this moral element altogether excluded the physical; and Vritra became Ahriman, who is engaged in an everlasting struggle with ORMUZD. Thus the great principle of Zoroastrian religion [DUALISM] is no suggestion of human experience or philosophical reflection, but an inevitable result of phrases employed to denote the phenomena of day and night. But although dualism is essentially polytheistic, the two great contending powers remained rather conceptions of the mind than beings of a recognised shape and form. The anthropomorphic tendency would show itself chiefly in less speculative races, and hence would be specially powerful among the Greeks, for whom the king of Olympus and the lord of light became beings of the same form and of the same passions with himself.

The worship of animals has been traced by many to a supposed universal worship of nature. Of this worship the episode of the cattle of Helios, in the *Odyssey* (xii.), is taken by many as furnishing some evidence. (Gladstone, *Homer and the Homeric Age*, ii. 412; Dasent, *Popular Tales from the Norse*, Introduction, xix.; Max Müller, *Comparative Mythology*, 53, 81; Cox, *Tales from Greek Mythology*, 118; *Gods and Heroes*, 68.) But although in Egypt some animals may have been regarded with special veneration, we have no proof of any such idolatry among the Greek or other tribes of the Aryan races. But their mythology supplies abundant illustrations of the way in which such a worship might be suggested. In the Vedic hymns, Indra has his cattle, which are daily driven to their pastures in the fields of the sky; his chariot is drawn by a bull, the same bull which bears EUROPA across the sea. Indra, again, has his horses, the Harits, which by the Jews (2 Kings xxiii. 11), as by other nations, were worshipped in that form, but which in the hands of the Greeks were transformed into the beautiful CHARITES. The animal worship thus suggested might be indefinitely extended, while it might also be degraded into the fetichism which imputes a virtue to inanimate and inorganic matter. The same process of developement would be seen in the idea of sacrifice, and the presentation of simple gifts would be followed by the surrender of the most costly treasures or the most precious life. In the early Vedic religion the horse, sacred to the sun, is also sacrificed to him; and the phrases which represented the death of the solar brides as following close on that of their lord, issued in the practice of SUTTEE.

But all these developements, although in the minds of the multitude they might almost extinguish a monotheistic belief, would not necessarily obscure it for men of deep and earnest thought. The Zeus to whom Achilleus prays in time of real trouble is not the Zeus who recounts the number of his earthly loves, but the Zeus to whom Æschylus appeals as incomprehensible yet perfectly just and righteous, and of whom Sophocles speaks as the father of the unfailing laws of purity and truth. In other words, polytheism began not with a conviction or belief, but from the necessities of human language, and as such it obtained a power over men proportionate to the degree in which they submitted themselves to the tyranny of words, and regarded names as something more than arbitrary titles attached to outward objects for the common purposes of life.

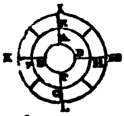
The theory of polytheism has been discussed in such works as Stillingfleet's *Origines Sacræ*; Kames, *Sketches of the History of Man*; Cudworth's *Intellectual System*; Vossius, *De Origine Idololatriæ*; but these writers had not before them that evidence on the earliest phases of human thought which has been more recently furnished by the results of philological science.

Polyxene (Gr. πολύξενος, from πολύς, and ξένος, *a stranger*). A name given by Hausmann to the ore of Platinum, as indicating the many new metals which are associated with it.

Polyzoa (Gr. πολύς, and ζῶον, *animal*). A class of compound animals resembling the Sertularians in their organs of support, but in their internal organisation approaching nearly to the compound Ascidians. The term is synonymous with the *Bryozoa* of Ehrenberg, to which the most extended currency is given.

Polyzonal Lens (Gr. πολύς; ζώνη, *zone*). The name given by Sir David Brewster to a burning lens constructed of several zones or

rings, each of which may be again composed of separate segments. In the annexed figure, A B C D is a central lens formed of one piece



of glass; E F G H is a middle ring, or zone, composed of four separate pieces; I K L M is another ring composed of eight segments, and surrounding the former. The number of zones, and of parts in each, may be as great or as small as we please.

This method of forming lenses is attended with several important advantages. The difficulty of procuring flint glass of sufficient purity to render it fit for the construction of a solid lens of large dimensions is removed, and the expense greatly diminished. If impurity exist in any of the spherical segments, or if an accident happen to any of them, it can easily be replaced. Another advantage attending the construction is, that it enables us to correct, very nearly, the spherical aberration, by making the foci of each zone coincide. Lenses of this kind are now made in great numbers by Messrs. Chance of Birmingham, and are extensively used both in French and English lighthouses.

Pomaceæ (Lat. pomum, *an apple*). That division of the natural order *Rosaceæ* to which the Apple, Pear, Quince, and Medlar belong. It differs from *Rosaceæ* proper in having an inferior ovary.

Pomegranate (Lat. malum granatum, so called from being full of grains). The fruit of the *Punica Granatum*, the pulp of which is acid and the rind highly astringent. The dried flowers, which are also astringent, were formerly used in medicine, under the name of Balaustine flowers.

Pomelloes. The name under which the smaller sized specimens of Shaddock, also designated Forbidden Fruit, are often sold in this country.

Pomœrium (Lat.). In Roman Antiquities, a space of ground, both within and without the walls of a city, kept free from buildings and consecrated by a religious ceremony. (See a memoir of D'Anville on the extent of ancient Rome, *Mém. de l'Acad. des Inscr.* vol. xxi. p. 206; and Dyer, *History of the City of Rome.*) When it was found necessary to extend the limits of any city, a new *pomœrium* was formed, and the former one desecrated.

Pomona. The Italian goddess of fruit-trees. At Rome the flamen pomonalis sacrificed to her every year for the preservation of the fruit. For the story of Pomona and Vertumnus, see Ovid, *Met.* xiv. 623. The name is derived from poma, *fruits*.

Pompholyx (Gr. πομφόλυξ, *a bubble*). An alchemical term for oxide of zinc.

Pompholyx. In Medicine, a vesicular eruption upon the skin.

Pompoleon. One of the names for the Shaddock, and in this country especially applied to the large-sized specimens. It is called Pampelmouse by the French.

Pomum Adami (Lat. *Adam's apple*). The protuberance in front of the neck formed by the thyroid cartilage and gland is so called.

Pond. An artificial excavation in the soil, or a natural hollow dammed up for the purpose of detaining water, generally made in fields in order to supply drink to pasturing animals. The essential difference between a pond and a lake is, that the former is artificial, the water being often ponded, or impounded, by a bank of earth thrown across a natural gutter, hollow, or bourne containing a stream. In Gloucestershire, Kent, and other counties where the soil does not abound in springs, the formation of ponds in the fields is as essential to the business of farming as the building of farm offices. In Berkshire and generally on the chalk downs impervious basins termed *dewponds* are made for the collection of rain-water for the use of sheep. And in dry countries where no springs exist, and where the supply of water is dependent very much on the collection of surface runnels, the formation of ponds connected with the land drainage of the neighbourhood has become a matter of great importance for the use of villages and hamlets. A pond in a garden, when of a round form, is termed a *basin*; and when of some length, with parallel sides, a *canal*.

Pone (Lat.). In Law, a writ which lay to remove actions out of the old common law courts of inferior jurisdiction, such as the Hundred Court, &c., into the superior courts at Westminster. It has fallen into disuse together with the jurisdictions which it was intended to control.

Pongamia (Malabar, pongam). *P. glabra*, an Indian tree, yields from its seeds an oil called Kurunj or Poonga oil, which is much used for mixing with lamp oil. It becomes solid in a temperature below 60° Fahr. The tree belongs to the great Leguminous family.

Pongo. This term was used to define the large adult form of the Orang-outan (*Pithecus satyrus*), which was supposed even in the time of Cuvier to be a distinct species; the term *pongo*, borrowed from Africa, being applied to denote the great anthropoid ape of the Malay Archipelago.

Pons Varolii. The bridge of Varolius An arched eminence of the medulla oblongata, formed by the crura of the cerebellum becoming flattened, and passing over the crura of the cerebrum.

Pont Volant (Fr.). [Bridges, Military.]

Pontee. In Glass Manufacture, an iron instrument by which the hot glass is taken out of the glass-pot.

Pontia (Gr. *of the sea*). A genus of butterflies, of which the common white or cabbage butterfly (*Pontia brassicæ*) is a well-known native species.

Pontifex (Lat.). The highest Roman sacerdotal title. Numa is said to have instituted four pontifices, chosen from the patricians; to which were added, long afterwards, four plebeians. Sylla increased their number to fifteen

The college was divided into two classes, distinguished by the epithets *majores* and *minores*; but it is not certain whether this difference of title marked out the patricians from the plebeians, or the more ancient members from the seven added by Sylla. The pontifices judged in all causes relating to sacred things, and inspected the conduct of the inferior priests. They were a self-elected body down to the latter ages of the republic, when the power of election was sometimes held by the people. It was finally vested in the emperors, who added as many to their numbers as they thought fit. The chief of the pontifices was called the *pontifex maximus*, and was always created by the people, being generally chosen from those who had borne the first offices in the state. His station was one of great dignity and power, as he not only had supreme authority in religious matters, but, in consequence of the close connection between the civil government and religion of Rome, exercised considerable political influence. The title of pontifex maximus being for life, Augustus never assumed it till the death of Lepidus, after which it was always held by himself and his successors to the time of Theodosius. The insignia consisted of the toga prætexta, and a conical woollen cap with a tassel (*galerus*). (*Mém. de l'Acad. des Inscr.* vols. xii. xv. xxiv. xxxvii.) From this word the title of pontiff in modern Europe is derived. *Supreme pontiff* is a common style of the pope.

Pontoons (Fr. ponton; Lat. pons, *a bridge*). A Military term, denoting portable floating vessels, forming the supporting part of the bridge equipment of an army. The Continental pontoons are of a flat-bottomed boat shape, and made of sheet-iron or wood. Our service pontoon is of tin, cylindrical, with hemispherical ends: the large one is 22 feet 3 inches long, and 2 feet 8 inches in diameter; the small one 14 feet 9 inches long, and 1 foot 7 inches in diameter.

Pony (Mr. Wedgwood connects this word with the Polish konik, the diminutive of kon, *a horse*, as the English poll answers to the Old Norse kollr, *the head*: *Dictionary of English Etymology*). The small variety of horse which is found in the northern regions of Europe. The ponies of Norway occasionally possess streaks on the hinder legs, like the quagga of Southern Africa.

Poonahlite. A variety of Scolecite occurring in slender rhombic prisms and radiating fibrous masses, resembling Needlestone. It is found at Poonah in Hindustan, where it forms large white kidney-form masses, with a pearly lustre, in amygdaloid.

Poop (Fr. poupe, Lat. puppis, *a ship*). A partial deck extending from about the mizen mast close aft, above the complete deck of the vessel. It is rapidly disappearing from modern ships, as a useless cause of leeway and a mark for an enemy's shot. A sea coming over the stern is said to *poop* the vessel.

In the vessels of the ancient Greeks and Romans, the highest part of the poop had a fan-shaped ornament, called by the former ἄφλαστον, and by the latter *aplustre*, which rose over the head of the steersman and served to protect him from wind and rain. On the column of Trajan a lamp is suspended from or before the helmsman. The aplustre was the ornament corresponding to the acrostolium which decorated the prow.

Poor Laws, England. The leading statute on this subject is that of Queen Elizabeth, 43 Eliz. c. 2, 'out of which' (says Dr. Burn) 'have arisen more litigation, and a greater amount of revenue, with consequences more extensive and more serious in their aspect, than ever were identified with any other Act of Parliament or system of legislation whatever.' Under this statute and those which followed grew up the system under which every *poor* person was entitled to relief from that parish in which he possessed a Settlement. The great abuses to which this law ultimately led are now matter of history. It was in order to reform them that the Poor Law Amendment Act of 1833 was passed (4 & 5 Wm. IV. c. 76), which is now (though amended by many subsequent statutes) the governing law. The administration of parochial funds was placed under the superintendence of the central board of poor law commissioners. The parishes were consolidated into unions, each administered by a board of guardians, partly elective and partly ex officio. The right of relief was maintained; but the mode of administering it was left under the control of the guardians, subject to the general rules of the poor law board. Several kinds of *settlement* known to the old and complicated law having been abolished, it can now be obtained only: (1) By birth, which is the primâ facie settlement of every one. (2) By parentage; or (3) by marriage; all legitimate children taking the last settlement of the father, and, after his death, of the mother, until *emancipation* (by full age, marriage, &c.), and illegitimate of the mother until sixteen. A woman also acquires her husband's settlement by marriage. (4) By renting a tenement under certain conditions. (5) By apprenticeship. (6) By holding an estate. (7) By payment of public taxes. A poor person also, though not acquiring a settlement, becomes *irremovable* from his place of abode after a certain period of residence. By the Union Chargeability Act of 1865 the cost of the relief of the poor has been thrown on the unions instead of the parishes, as formerly; and questions arising on the law of settlement may be expected to be less frequent than heretofore.

Poor Laws, Ireland. Until the present reign, the poor in Ireland had no legal right to relief; while the system of voluntary assessment, so extensively established in Scotland, hardly existed. In the first year of Victoria the general system of the English poor law was introduced; and by 10 & 11 Vict. c. 90, a board of commissioners for administering the law for relief of the poor in Ireland is established, distinct from that of England.

Poor Laws, Scotland. The Poor Law Amendment Act of Scotland was introduced in 1845 (8 & 9 Vict. c. 83). It establishes a *board of supervision* of ten members (one paid), with power to make rules and regulations; *burghal parishes*, or combinations of parishes with boards of *managers of the poor*, with power to raise funds by compulsory assessment; and gives the *destitute poor* a right of relief in the parish to which they *belong*, the settlement being obtained by reference. Prior to this statute, the relief of the poor was effected by voluntary assessment: and in 1854, 194 parishes still retained this system, while 689 had adopted the *compulsory*.

Poor Rates. [PAUPERISM.]

Pope (Lat. papa). This word, signifying father, was in earlier times applied indiscriminately to all bishops and presbyters; but in the Western church the term has long been confined to the bishop of Rome, who is also designated by Roman Catholics as the Holy Father. In the Greek church it is still the title of all priests. [PAPACY.]

Poplar (Fr. peuplier, Lat. populus). The common name for the trees of the genus *Populus*. These trees are of rapid growth, and consequently their timber is soft, light, and of a loose texture; they are remarkable for a greater or less amount of tremulous motion in the leaves, occasioned by the length and slenderness of the leafstalk, which, instead of being flattened horizontally, or in the same plane with the leaf, as is the case with the generality of trees, are compressed vertically, so that the plane of the leaf and that of the stalk form a right angle with each other. The Lombardy Poplar, *P. fastigiata*, is the formal cypress-shaped tree with perpendicular slender branches common in suburban gardens, but scarcely ornamental except when its taper-head rises above a mass of round-headed trees and breaks or relieves a too continuous horizontal line. Its timber is of little use, except for packing-cases. The Black Italian Poplar, *P. monilifera*, is the fastest-growing of all the species, and sends up a remarkably straight stem. The timber of *P. alba*, the White Poplar or Abele, is of little value; but that of the Grey Poplar, *P. canescens*, a tree of slower growth, is used by the carpenter, turner, and millwright for many purposes. In *P. tremula*, the Aspen, the leaves are especially liable to the tremulous motion peculiar to the family. *P. balsamifera*, the Tacamahac, is remarkable for its fine foliage in early summer, and for the pleasant balsamic odour of its buds and leaves.

Poplin. A kind of fine woven stuff, made of silk and worsted.

Popliteal (Lat. poples, *the ham*). Relating to the posterior part of the knee-joint or *ham*.

Poppets. Timbers used as shores to support the cant-bodies of the bow and stern on the bilgeways preparatory to the launching of a ship.

Poppy (A.-Sax. papig, Lat. papaver). The name commonly applied to the species of PAPAVER. The Opium Poppy, which is the most important species, is *P. somniferum*.

Population. In Political Economy and Statistics, the number of persons occupying the soil of any given country, and maintained by its produce. Enquiries into the amount and distribution of the population in various civilised communities have always a great interest, and are eminently illustrative of important economical principles. The theory of rent, the cost of producing utilities, the laws which govern prices, the circumstances which facilitate or thwart human industry, the stimulants and consequences of emigration, and many other similar subjects, are connected with the facts of population, and the law of its increase.

The population of every settled or ancient country, as contrasted with the population found on such sites as are not yet fully occupied, is the whole number that subsists on its produce. The amount, therefore, and the character of the food habitually required by the people of any given country, is one factor contributing to the total, the rate of production is another, and the power of purchasing and carrying supplies from foreign regions is a third. Whatever may be collected from these elements will, except under peculiar and anomalous circumstances, tend to the aggregate population of the country. Nor does this apply to countries only, for exactly the same causes will be found to govern the growth of cities. When the operation of the causes mentioned above is disturbed or weakened, it is not possible that cities should be large and increasing; but when these causes are fully operative, there is no necessary limit to the aggregation of mankind and the growth of towns. A little further explanation will serve to show the significance of these coefficients.

The first-named cause has not been sufficiently recognised by economists. If the mass of a community demands habitually a high standard of living, and will not, except under temporary pressure, submit to a lower rate, population will not increase in the same ratio as when an inferior or low standard is accepted. For instance, from the earliest recorded times, the staple food of the people of England has been wheaten bread. Now wheat is not only relatively, i.e. by virtue of the demand for it, but absolutely, i.e. by the cost of cultivating it, the dearest of all grain crops. It takes more labour to grow a bushel of wheat than it does to grow a bushel of any other kind of grain. Hence the population, being accustomed to this food, and never voluntarily using any other, cannot become larger than the number which can be maintained on the wheat grown and purchased for the use of food. On the other hand, the Irish subsist generally on potatoes, the Scotch on oatmeal: the one being the cheapest food that can possibly be procured; the other, bulk for bulk, the cheapest kind of grain. Hence there is a tendency among these nations to increase up to the average amount which can be procured of these kinds of food, and, equal amounts

of labour being devoted to cultivation, to multiply in excess of a nation which subsists on wheaten bread, by all the difference between the produce of the one and the produce of the other kind of labour. Nor is this the only consequence. When a dear kind of food is consumed, it is possible on the occurrence of a temporary scarcity to take refuge in an inferior kind; but when a cheap kind is accepted, no such opportunity is afforded. In other words, when a nation lives on wheat, it may suffer dearth, but hardly famine; when a nation lives on potatoes or oats, it is always within danger of famine. [FAMINE.]

By the rate of production is meant the aggregate quantity of food which agricultural science can extract from the soil. In a previous article [LAND] it was stated that this, taking *all* produce into account, is from ten to twelve times more than was procured by the skill and toil of the mediæval agriculturists. It does not seem, however, that the number of persons employed in agriculture has greatly increased, for much of this larger measure of production is due to judicious selection, continuous cultivation, and considerable outlay of capital in permanent improvements. If, however, greater produce is procured at less cost, a continuously increasing number of persons, engaged in other than agricultural pursuits, can be maintained out of the gross produce; and in case every facility be given to production, by the removal of obstacles to the fullest employment of all the powers which exist in the soil or can be induced upon it, it seems likely that the rate of production would be considerably increased. There must be, of course, a limit beyond which production could not be extended; but at present the energies of labour have not nearly reached this limit.

But the whole amount of food needed for the maintenance of labour in densely populated countries is not produced from the soil of these countries, any more than the food of the inhabitants of towns is got by cultivating the land within the boundaries of the town. It is procured by exchange from abroad. The industrial population of a town is engaged in producing articles which may be exchanged advantageously to both parties for the products of agricultural labour, or in importing foreign produce for distribution among the mass of the community. In the same way, if a country is favourably situated for manufacture and trade, it may stand to other parts of the world in the position of a town to the rural region around it; and just in the same way as it would be a grievous hardship to the inhabitants and a serious hindrance to the prosperity of a town, if the municipal magistrates put any impediment in the way of the introduction of food into it, so it is a mischievous policy which puts any difficulty in the way of the importation of food from foreign countries. Many ages, indeed, must elapse before the population of the world becomes so large that its agricultural regions will have no surplus beyond the supply of their own wants, or the cessation of imports from such regions may be induced by the fact that their domestic manufactures will supply them as well as foreign countries do now. Meanwhile, the facilities of transit keep pace with the extension of the area from which supplies are procured. The creation of a railway through a tract of the Western States of the American Union, may be a means by which wheat and other kinds of grain may be exported in quantities sufficient to supply all that may be needed by this country in excess of its own production, although the rate produced by the acre may be very low. It appears, then, that the alarms expressed by many economists as to the narrow margin from which future supplies of food can be obtained, the natural outlets, namely, of rivers, and the sea coast, are not warranted by facts, since we must add to these means of transit the equally important agency of railroads. Furthermore, the cost of freight is diminishing, and seems likely to diminish. Some sanguine persons have anticipated, that in case the supply of coal in this country should fail, it might still be possible to maintain special manufactures by the importation of this necessary from the Pennsylvanian fields; much more, therefore, should we be able to depend upon abundant supplies of wheat and other grain.

There may be, therefore (by the extension of foreign trade, by the manufacture of commodities which command by their cheapness and utility an extended market, by the cultivation of amicable relations between communities, and the abandonment of those jealousies, suspicions, and rivalries, which have been in past times so mischievous to all the interests of mankind, by the adoption of systems of mutual law, and by the practical acknowledgement that for the purposes of mutual benefit all civilised communities have common duties and a common being), an increase of population in certain regions favourably situated for manufacture and commerce, which shall be at once far in excess of any density with which we have yet been acquainted, and far more healthy and satisfactory than even the most favourable instances that have occurred. Much of the anxiety which has been justly expressed as to the social consequences of a redundant population, has been occasioned by the acts of that policy—now, it is to be hoped, exploded—which saw in the growth and prosperity of one community a menace to another, and strove to insulate, or at least to control, instead of harmonising, the commercial action of different states.

The Law of the Increase of Population.—Most governments have encouraged, either by direct privilege or by penalties on celibacy, or at least by social and religious sanctions, the growth of population. In Rome there was a tax on celibates, and a privilege accorded to those who had three children. The dense population of India and China, despite frequent wars and famines, is due in great measure to the religious obligation of marriage. The birth

of a male child is one step to heaven in the Brahmanical catalogue of good works, and a Chinese who has no male offspring is looked on as the victim of a serious misfortune, for he is thus deprived of that posthumous worship which, under the name of honour due to departed ancestors, forms, it would appear, the most fundamental tenet of faith among the Buddhist laity. So, again, the heaviest charge brought against the monks of the pre-Reformation epoch was the fact that by their celibacy they did not contribute to the growth of the people. Marriages were encouraged among the poor under the old law of relief by the allowance system, and until lately a relic of the ancient theory of population was to be found in the exceptional tax levied on bachelors who kept male servants.

Mr. Malthus, in an *Essay on Population*, written and published in 1798, in answer to a work of Mr. Goodwin's entitled *Political Justice*, has the merit of having been the first to discover and expound the principles on which the growth of population is effected, and of having shown that the policy hitherto pursued of encouraging early marriages among the working classes was unwise and dangerous. It must be remembered, in connection with the publication of this theory by Mr. Malthus, that the epoch in which he wrote was one of an exceptional character. The nation was engaged in a war more vast and exhausting than any in which it had ever been engaged. Beyond its own unprecedented military expenditure, it was subsidising its foreign allies. Cash payments were suspended at the banks, and the taxes levied, in utter defiance of all economical maxims, inflicted the maximum loss on the community, at the minimum gain to the state. Nor was there at the time either manufacture or trade by which the scanty supply of home produce could be supplemented from foreign sources.

Mr. Malthus stated his theory in the following formula. Population increases in a geometrical, food in an arithmetical ratio. The children of one generation are the parents of the next, and the number of persons born of each marriage being on an average double or treble the number of the parents, the growth of population would, if unchecked, go on according to the progression of 2, 4, 16, &c. Increased quantities, however, of the necessaries of life can be attained only by increased labour. Thus, were there no external checks, population would soon outrun the means of subsistence, and these checks Mr. Malthus found to be vice, misery, and moral restraint. Stated so nakedly, the theory seems exceedingly repulsive, and it was in fact so unpopular, that the term *Malthusian* was commonly used to denote a harsh and unfeeling view of human life. Nor was it difficult, for those who were offended at the conclusions gathered, to show that the premisses were overstated. It does not follow that all marriages are fertile; on the contrary, it is notorious, as is learnt from the records preserved of particular families, that many are not prolific; and if families are by any circumstances so separated as to be precluded from additions external to them, it is found, that, however numerous they are at first, they rapidly die out. It is very doubtful whether, supposing a nation were kept free from foreign immigration, its numbers would notably increase, and it is probable that the ordinary conditions and habits of modern civilisation are not by any means favourable to fecundity. It is alleged that the circumstances under which population increases most rapidly, at any rate where the births are in great excess, are those rather of hardship than of plenty; and this so remarkably, that Mr. Doubleday has made it the foundation of a theory of population, extravagant perhaps, but still plausible, in which the leading feature is that human beings are more fertile when, as in late marriages, they are least likely to be represented in their offspring, because they are near the time in which the reproductive functions cease; just as (to use Mr. Doubleday's language) a fruit-tree which is failing puts out its largest crop just before it ceases to bear any more. That marriages are more fertile when the parents are exceedingly poor and driven to great straits in order to procure subsistence, was seen by Adam Smith; that the danger, therefore, of excessive population lies in the pre-existent misery of parents, has been urged by many opponents of the doctrine of Malthus. Again, it may be doubted whether invention and adaptation in agricultural science may not invert the characteristic which Malthus thought he discovered in the rule of the production of food. It is probable that, since the time in which Malthus wrote, the rate of production has been doubled, and this at no greater charge for labour. It is certain that, in the developement of modern civilisation, in the abandonment of international jealousies, and in the slow but certain influence now exercised by the best interests of humanity against the selfish fears of administrations, the state of things in which any country makes itself voluntarily like a beleaguered city in its seclusion from the reciprocities of trade, is getting more and more remote. The value of the theory which Mr. Malthus announced lay, first, in its instant application to the social practice of his day, and in the truth which it contained; its error, a natural error, lay in the fact that at that time it could hardly be expected that a better and wiser course of international policy would lead men to understand that the interests of humanity were far more powerful than those of a miscalled patriotism.

The risks of over-population, to which Malthus called attention, are therefore, we believe, remote in the present time, partly because the area from which the supply of food can be procured is so extensive and so extensible, partly because the customary food of the people of England is found in the most costly kind of grain. That the condition of many who live by wages in this country, and especially in

agricultural districts, is one of great poverty, is doubtless true; but it must be remembered that this distress is being lightened by a real rise in wages; the average earnings, even of agricultural labourers, having considerably increased, and the power of purchase, owing to free trade in corn and the reduction of taxation, being far greater than twenty years ago. Nor can there be a doubt, that, if agricultural and other labourers would exercise the same prudence in postponing their marriage which is practised in every other condition of life, by abstaining from marriage till such time as they were possessed of some capital, and were, comparatively speaking, independent of the common casualties of their calling, their condition, even if they had subsequently as many children as now, would be infinitely bettered. As it is, they clog themselves in the very beginning of their industrial life, lose the power of moving from place to place, and with this inability abandon all hope and energy towards improving their prospects. In Cumberland and Westmoreland, the average rate of agricultural wages is 16*s.* a week, and the labourers will sooner emigrate than take less. That they may be able to do so in case the necessity arises, they take care to be possessed of some savings.

It does not follow, as some persons have rather hastily argued, that a slow increase or stationary position of the population in any one country is a sign of greater prudence on the part of its inhabitants. The people may be in such countries close upon the margin of subsistence. To discover whether this be the fact, we must take the ordinary earnings of the poorer classes, whether they be small proprietors or labourers for wages, and compare the amount with the price of the necessaries of life. Great stress has been laid, for instance, on the prudential habits of the French, and some among the Germans. But if it be found that the average means of subsistence possessed by these people is scanty, and much below that, for instance, of the English labourer, the condition of over-population is reached already. It must be observed, also, that where legislative arrangements prevent marriage, there is, in ordinary cases, sure to be a great increase of bastardy. In Munich, for instance, where regulations prohibiting marriage exist, and a system which has been incautiously praised is in full force, the illegitimate births are nearly as numerous as the legitimate, and the industrial energies of the community are of the lowest order. On the whole, we may conclude, that if the working classes in this country possessed a little more prudence in delaying marriage, they might secure to themselves a larger measure of independence, and ultimately a larger rate of wages, than they have ever yet experienced.

The subjoined table gives the population of the principal European communities, with that of the United States, and as far as possible the decennial percentage of increase:—

States	Date of Census	Population, 000 omitted	Area sq. miles	Population per sq. mile
Belgium	1856	4,530	11,313	401
Netherlands	1861	3,373	10,905	309
Great Britain and Ireland	1861	29,071	119,924	242
Italy	1864	21,777	98,784	221
German States	1861	18,071	95,347	189
France	1861	37,382	211,852	176
Switzerland	1860	2,534	15,233	157
Prussia	1861	18,497	107,300	156
Austria	1857	35,019	236,311	148
Denmark	1860	1,600	14,493	110
Portugal	1858	3,585	36,510	98
Spain	1857	16,302	182,758	90
Turkey in Europe	estimate	15,500	203,628	76
Greece	1861	1,329	19,340	68
Russia in Europe	1858	65,845	2,043,399	32
Sweden and Norway	1861	5,351	291,903	18

Density of Population on the Globe.

	Population, 000 omitted	Area, 000 omitted	Population, sq. mile
Europe	280,000	3,701	75
Asia	780,500	17,805	44
Africa	80,000	11,475	7
America	79,000	15,840	5
Australasia	1,500	2,582	1

Populin. A crystallisable substance separated from the bark of the poplar-tree, *Populus tremula.*

Porcate (Lat. porca, *a ridge*). In Entomology, when a surface has several parallel elevated longitudinal ridges.

Porcelain. [POTTERY.]

Porcelain Clay. [KAOLIN.]

Porcelain Spar. A silicate of alumina, lime and soda, with chloride of potassium; found at Obernzell in Bavaria.

Porcellanite or **Porcelain Jasper.** Clay altered by heat, so as frequently to resemble jasper.

Porch (Fr. porche). A small building erected to shelter the entrance of a church, or other edifice. Porches had frequently a chamber over them, used as a chapel or a muniment room.

Porcupine (Ital. porcospinoso). The name of a genus of Rodents (*Hystrix*) distinguished by the developement of free and voluntarily movable spines amongst the hair. They are found throughout Southern Europe, and allied generic forms exist in North America. [HYSTRICIDÆ.]

Porcupine Wood. The hard outer portion of the trunk of *Cocos nucifera.*

Pores (Gr. πόροι). In Astronomy. [SUN.]

PORES. In Natural Philosophy, the small interstices between the particles or molecules of matter which compose bodies. There are many considerations which prove that all bodies, even the densest, are composed of molecules, not in absolute contact, but separated from each other by intervals, which, though so small as to be inappreciable to the senses, have nevertheless a magnitude con-

siderable in respect of the molecules themselves; and it has been inferred that gold has more pores than solid parts; whence any substance of the specific gravity of water must have many times more pores than solid parts.

Porifera (Lat. porus, *a pore*, and fero, *I carry*). A name invented and applied by Mr. Hogg to a group of Polypes, including the genera *Cellepora*, *Millepora*, and *Tubulipora*: also used by Dr. Grant to designate the class of organised beings including the marine and freshwater sponges.

Porism (Gr. πόρισμα, from πορίζω, *I supply*). In Geometry, this word is defined by Prof. Playfair to be 'a proposition affirming the possibility of finding such conditions as will render a certain problem indeterminate, or capable of innumerable solutions.'

The following may serve as an example of a porism:—

A triangle being given in position, a point in it may be found such that any straight line whatever being drawn through that point, the perpendiculars drawn to this straight line from the two angles of the triangle which are on one side of it, will be together equal to the perpendicular drawn to the same line from the angle on the other side of it.

According to Pappus, the porisms constituted one of the eight subjects which formed the ancient geometrical analysis. Euclid composed a treatise on porisms in three books, of which no trace now remains, except some obscure hints preserved in the mathematical collections of Pappus. From the manner in which the porisms are mentioned by Pappus, it is evident that the ancients set a high value on this class of propositions; but the description which he has given of them is so vague, that geometers were long unable to divine his meaning, or to discover the peculiar circumstances in respect of which a porism differs from an ordinary problem. The subject, indeed, baffled the ingenuity of the most eminent mathematicians, until it was taken up by Dr. Simson, of Glasgow, who at length succeeded in restoring a great number of Euclid's porisms, together with their analysis. The propositions thus restored form a part of his posthumous works, published in 1776, at the expense of Earl Stanhope. It still remained, however, to enquire into the probable origin of the porisms, or the steps by which the ancient geometers had been led to their discovery; and also to point out the relations in which they stand to other classes of geometrical truths. This was accomplished by the late Professor Playfair, in an admirable paper 'On the Origin and Investigation of Porisms,' published in vol. iii. of the *Transactions of the Royal Society of Edinburgh*, and afterwards in the third volume of his collected works, Edin. 1822.

The most recent and perhaps the most valuable work on the subject is by M. Chasles, and is entitled, *Les trois Livres de Porismes d'Euclide rétablis pour la première fois, d'après la Notice et les Lemmes de Pappus et conformément au sentiment de R. Simson sur la forme des Énoncés de ces Propositions*, Paris 1860.

Porosity. A property of matter, in consequence of which its molecules are not in absolute contact, but separated by intervals or *pores*. The quantity of matter in a body is inversely as its porosity; whence the ratio of the porosity of one body to another may be determined from their weight. [Pores.]

Porphyry (Gr. πορφύρα, *purple*). A term in common use among geologists, to signify any rock in which crystals are embedded in an earthy or compact base. Thus granite in which crystals of felspar and mica are embedded in crystalline quartz, but not with crystals of quartz, is a porphyritic rock, and a mass of felspar with crystals of quartz and mica would be spoken of under the same general term. It will be evident, therefore, that the term is extremely *inclusive*, perhaps too much so to admit of a good definition. Many of the varieties of porphyry are named from their base, as greenstone porphyry, hornstone porphyry, &c.

The original meaning of porphyry is connected with the colour (red) which characterised the syenites of Egypt; but the use of the term is now altogether technical, and quite independent of colour.

The ordinary kinds of porphyry used in the arts are grey, red, and purple, the latter including a great variety of tints. They are not worked on a large scale, except in Russia and Scandinavia, where the raw material is obtained from large boulders lying on the surface of the ground.

The difficulties involved in the manipulation render the work of cutting and polishing so costly, that the objects manufactured are rather imperial presents than objects of commerce.

It has been supposed that in former times there were greater facilities for working porphyry than now exist, but this is not probable. Like all stones, the material was no doubt much softer when recently taken from the quarry than when obtained from boulders exposed for centuries to the air; but it was chiefly the small value of labour, and the indifference to the time needed for the work, that enabled the ancient Egyptians to cut and polish the magnificent vases and columns so common in the museums throughout Europe.

Porpita (Gr. πόρπη, *a buckle*). The name of a genus of sea-nettles (*Acalephæ*), characterised by an internal circular flattened disc of a calcareous and horny texture.

Porpoise (Fr. porc-poisson). [Phocæna.]

Porrect (Lat. porrectus, part. of porrigo, *I extend*). In Zoology, when a part extends forth horizontally, as if to meet something.

Porrigo (Lat. *scurf*). The ringworm, or scald-head.

Port. The canals or orifices provided for the passage of fluids in machinery are called *ports*; thus *steam-ports, water-ports, gas-ports*, are commonly mentioned.

The Latin words porta and portus, the former meaning *a gate*, the latter *a haven*, are probably akin to the Greek πύλη, περάω, and the English *ford*. [FRITH.]

PORT. [HARBOUR.]

PORT. The opening or embrasure in the ship's side for a gun. The ports of the lower deck are defended, when at sea, by strong covers hanging from hinges; the ropes by which these are held up or open are called *port lanyards*, and consist of a pendant passing through a leaded hole in the side with a tackle.

PORT. In Navigation, the modern term for *larboard*.

Port Royalists. The name popularly given to the members of the celebrated convent of the Port Royal des Champs. It was founded about 1204 by Matthieu de Marli, on the eve of his departure for the Holy Land; and it gradually acquired such importance as to secure for it a prominent place in the history of Europe. For the details of its varied fortunes, and the religious controversies which it carried on in the seventeenth century, the period of its greatest importance, we refer the reader to the learned work of Reuchlin (*Geschichte von Port Royal*), and to Sainte-Beuve's *Histoire du Port Royal*. It was abolished by Louis XIV. as a nest of Jansenists and heretics. Among the distinguished names connected with the Port Royal are those of Lancelot, Pascal, Arnauld, Nicole de Sacy, and Tillemont. The school books which were published for the use of that institution were translated into all the languages of Europe, and maintained their reputation long after its abolition; and though they are now fallen into disuse, the following deserve especial mention: 1. *Nouvelle Méthode pour apprendre la Langue Latine*; 2. *Nouvelle Méthode pour apprendre la Langue Grecque*; 3. *Grammaire Générale, &c.*

Port-fire. In Artillery, the *common port-fire* consists of a paper case about sixteen inches long, driven with a composition which burns at the rate of rather more than one inch a minute.

The *slow port-fire* consists merely of paper impregnated with saltpetre, and rolled into a solid cylinder about sixteen inches long, which will burn from two to three hours.

Portal (Lat. porta, *a gate*). In Anatomy, this term is applied to a system of veins that ramify like arteries, and send the blood from trunks to branches in the substance of the liver. The portal system is derived in mammals from the veins of the abdominal organs of digestion, which form a common trunk, called *vena portæ*. This subordinate kind of circulation in the liver is called the *portal circulation*, and the blood it transmits is called the *portal blood*. The blood of the portal veins differs from other venous blood in being of less specific gravity, darker, and incapable of being rendered bright by the contact of salt or oxygen; in containing only about half the ordinary quantity of fibrin, and in containing less albumen, but more red globules, and nearly twice the usual amount of fatty matter.

PORTAL. In Architecture, the lesser of two gates, when they are of two dimensions, at the entrance to a building.

Portcullis (Fr. portecoulisse). In Fortification, a sliding frame of wood or iron, shaped like a harrow, and formerly hung over the gateway of a fortified place, to be let down in a vertical groove, if the outer gate should be forced.

Porte, The Sublime. The official title of the government of the Ottoman Empire: said to be derived from a gate of the palace at Broussa, the original metropolis of that empire, called Bâb Humayoon, *the sublime gate*.

Porter (originally called *porter's beer*). A liquor brewed from malt, part of which has been more highly dried than that which is used for ale. It is hopped in the same way as ale; and its deep colour is finally given to it by roasted or parched malt. Porter was first brewed in 1722. The malt liquor previously drunk consisted of three kinds—ale, beer, and *two-penny*; and a mixture of either of these kinds was a favourite beverage under the name of *half-and-half*; or a mixture was drunk called *three threads*, consisting of equal portions of each of the above kinds of liquor, for a draught of which the publican had to go to three different casks. About 1722, Harwood, a London brewer, commenced brewing a malt liquor, which was intended to unite the flavours of ale and beer, or ale, beer, and *twopenny*; and having succeeded, he called his liquor *entire*, or *entire butt*; a name intended to intimate that it was drawn from one cask or butt only. A mixture of ale or porter, drawn from different casks, is very commonly drunk in London at the present time. Harwood's liquor obtained the name of porter from its consumption by porters and labourers. From 1722 to 1761, the retail price of porter was 3*d*. per pot, when it was raised to 3½*d*., at which it continued till 1799; it has never been higher than 6*d*., nor during the present century lower than at the present time, when the price is 4*d*. Since the abolition of the beer duties in 1830, the price has been 33*s*. per barrel. [TAXATION.]

Portico (Lat. porticus). In Architecture, a place for walking in under shelter, occasionally raised after the manner of a gallery with arches. Sometimes the portico is vaulted, sometimes it is covered with a flat ceiling. The most usually recognised application of the word is to the projection supported by columns placed before a building, and in this case it may be tetrastyle, hexastyle, octostyle, decastyle, and so forth, according to the number of its columns.

Portion (Lat. portio). In Anatomy, a term applied to two branches of the seventh pair of nerves; the *portio dura*, or hard portion, and the *portio mollis*, or soft portion: the former is the facial nerve, the latter the auditory or acoustic nerve.

Portion, Disposable (Fr. quotité disponible). In French Law, that portion of his property which a person may leave by will to

whom he pleases: amounting to a fourth where the testator has three or more children; a third, where he has two; half, where he has one child, or no child, but relatives capable of succession on the side both of father and mother; three-fourths, where he has relatives only in one ascending line.

Portite. A silicate of alumina, magnesia, and lime, found in the gabbro rosso of Tuscany, and named after M. Porte.

Portland Powder. A medicine consisting of equal parts of the roots of *Aristolochia rotunda* and *Gentiana lutea*.

Portland Stone. An important building material obtained from the upper part of the oolitic series of rocks, and chiefly quarried in the island of Portland. It is perhaps the best building stone in England when well selected, but it is heavy and dear, and there are very bad portions that must be carefully avoided. The best bed is near the top, and is from three to eight feet thick. Other inferior but still excellent beds are much worked. St. Paul's Cathedral and Greenwich Hospital are both excellent specimens of Portland that has resisted the attacks of time and weather in a London atmosphere.

Portland Vase. A celebrated cinerary urn or vase, long in the possession of the noble family of the Barberini at Rome (whence it was called the Barberini vase). From the Barberini it passed into the possession of the Portland family, who deposited it in 1810 in the British Museum. This beautiful specimen of ancient art was found in the tomb of the emperor Alexander Severus and his mother Mammæa. It is described by Montfaucon (*Antiq. Expliqué*, tom. v.), who was evidently mistaken in representing it as formed of a precious stone. The substance is said to be of glass, or composition; it is of a deep blue or violet colour, and the figures in the scene depicted on it are white. The subjects are mythological, but have been very imperfectly explained. (See two memoirs upon it, by Dr. King and W. Marsh, in the 8th volume of the *Archæologia*, and one by Dr. Darwin in the Notes to his *Botanic Garden*.) The late Mr. Wedgwood made a mould of this vase, and took from it a number of casts wrought with the greatest skill, and perfectly resembling the original.

Portrait (Fr.). In Painting, strictly the picture of any object taken from nature, or generally the representation of an individual, or, more strictly speaking, of the human face, painted from real life. Portraits are of full-length, half-length, kit-cat size, and three-quarters, &c.; and are executed in oil or water colours, in crayons and in miniature. Whole lengths and half-lengths vary in size; the kit-cat, so called from the size chosen by the old club of that name, from Christopher Cat, the master of the house in which the club was held, was a yard in height, by three-quarters of a yard in width.

Portraits are almost coeval with the earliest efforts in painting; they were not uncommon among the Egyptians. The Greeks exhibited iconic figures of their generals, in their public buildings, shortly after the Persian war, the Romans painted their portraits upon their shields, and these were sometimes dedicated in the public temples after the death of the owners. They also placed portraits of writers in the public libraries, over the cases containing their works; and the upper classes preserved wax portraits of their ancestors, which were carried in the funeral procession, when any distinguished member of the family died. These were the *imagines majorum*, the possession of which constituted a proof of nobility, as none but those families who had borne some curule magistracy had the privilege of having their portraits [Jus]; families boasted of their smoky images, *fumosæ imagines*, to show the antiquity of their houses.

Among great portrait painters are most conspicuous, Apelles, John van Eyck, Leonardo da Vinci, Raphael, Titian, Tintoretto, Moroni, Sebastian del Piombo, Jacopo da Pontormo, Bronzino, Velazquez, Holbein, Rubens, Vandyck, Rembrandt, Reynolds, Gainsborough, &c. (Wornum, *Epochs of Painting, &c.* 1864.)

Portreeve or **Port Greve** (A.-Sax. gerefa). The principal magistrate in Anglo-Saxon ports and maritime towns. According to Camden, this was the ancient title of the officer who was afterwards called mayor of London.

Portulacaceæ (Portulaca, one of the genera). A small order of hypogynous Exogens of the Silenal alliance, known by their consymmetrical flowers, their amphitropal ovules, and alternate leaves without stipules. The typical genus is *Portulaca*, one species of which, *P. oleracea*, under the name of Purslane, was formerly cultivated as a potherb.

Poseidon. In Greek Mythology, a son of Kronos and god of the sea, standing to Nereus in a relation corresponding to that of Phœbus to Helios. [Zeus.]

Posidonia Schist. A somewhat important bituminous shale belonging to the lias, and very extensively distributed over Europe. The *Posidonia* is a flat bivalve shell. It appears often in incredible abundance, almost composing a mass of black shale, but mixed up with so large a quantity of carbon in the form of bitumen, that it is valuable for distilling. There are now several establishments in Germany where the Posidonia schist of the lias is worked for distillation.

Position (Lat. positio, from pono, *I place*). A rule in Arithmetic, called also the rule of supposition, or *rule of false*. It consists in assuming a number, and performing upon it the operation described in the question, and then comparing the result with that given in the question, in order to discover the error of the assumption. Writers on arithmetic divide the rule into two parts, *single position* and *double position*; the former comprehending those questions in which the results are proportional to the suppositions, and where, consequently, only one assumption is required;

the latter those in which the results are not proportional to the suppositions, and where two suppositions are necessary in order to deduce the true answer. To simple position belong such questions as the following: What number is that from which, if a third and a fourth of itself be subtracted, the remainder is 60? Double position comprehends questions of this sort: What number is that which, being multiplied by 6, the product increased by 18, and the sum divided by 9, the quotient shall be 20? It will be observed that both these questions are immediately solved by a simple algebraic equation. Position is also called the *rule of trial and error*, and is sometimes employed with good effect in approximating to the roots of numerical equations.

Position. In Painting, the placing of the model in the manner best calculated for the end in view by the artist.

Position, Angle of. In Astronomy, the angle made by one or more components of a double or multiple star with the primary, referred to the direction of the diurnal motion. It may also indicate the direction of a comet's tail, &c.

Positive Electricity. [Electricity.]

Positive Quantity. In Algebra, this term denotes an affirmative or additive quantity, which character is indicated by the sign +, called, in consequence, the *positive sign*. The term is used in contradistinction to *negative*; negative quantities being such as are subtractive, and marked by the sign —, which is called the *negative sign*. [Sign.]

Positivism. This word is commonly used to designate the system of philosophy maintained by M. Comte, who is vaguely supposed to have originated a method unknown to philosophers before his time. Like most popular notions, this is a mistake. M. Comte certainly strove to systematise the whole field of knowledge; but the ground on which he raised his gigantic fabric is that on which all philosophers who have really promoted the advance of science, have commonly worked. His fundamental doctrine, in his *Cours de Philosophie Positive*, is that we have no knowledge of anything but phenomena, and that our knowledge of phenomena is relative, not absolute, i. e. that we know not the essence or the real mode of production of any fact, but only its relations to other facts in the way of succession and similitude. This doctrine is practically that of Galileo, Bacon, and Descartes; and to this conclusion, that the only knowledge accessible to us is that of the successions and sequences of phenomena, we owe the whole progress of science during the last four centuries. But the distinguishing characteristic of M. Comte's philosophy was the hypothesis that all human conceptions pass through three stages, the theological, the metaphysical, and the positive. The nomenclature is his own, and although it is open to many objections, his conceptions cannot be adequately unfolded except in his own terminology. The theological stage of thought he again subdivided into Fetichism, Polytheism, and Monotheism, 'the successive transitions being prepared, and indeed caused by, the gradual uprising of the two rival modes of thought, the metaphysical and the positive, and in their turn preparing the way for the ascendency of these; first and temporarily of the metaphysical, and lastly of the positive.'

This doctrine, which takes no account of anything but an ascertained order of phenomena, is not unfrequently charged with atheism. M. Comte apparently rejected the idea of the dependence of nature on an Intelligent Will; but the adoption of his principle of experience, which is the principle of Bacon and of Newton, by no means necessarily involves his conclusion. The positive theory merely throws back the question of an Intelligent Will, instituting the cosmos, to the origin of all things. 'The laws of nature cannot account for their own origin. The positive philosopher is free to form his opinion on the subject, according to the weight he attaches to the analogies which are called marks of design, and to the general traditions of the human race.' It is compatible with M. Comte's system to believe 'that the universe was created, and even that it is continuously governed by an intelligence, provided we admit that the intelligent Governor adheres to fixed laws, which are only modified or counteracted by other laws of the same dispensation, and are never either capriciously or providentially departed from. Whoever regards all events as parts of a constant order, each one being the invariable consequent of some antecedent condition or combination of conditions, accepts fully the positive mode of thought, whether he acknowledge or not a universal antecedent on which the whole system of nature was originally consequent, or whether that universal antecedent is conceived as an intelligence or not.'

M. Comte has been also charged with repudiating metaphysics; but it is a mistake to suppose that he interdicted himself 'from analysing or criticising any of the abstract conceptions of the mind,' although with all his strength he opposed the ideas which regard mental abstractions as real entities. His crusade against these realistic theories, which the Baconian philosophy professes utterly to eschew, led him into an elaborate and masterly survey of the developement of human thought and knowledge, the result of which showed that fetichism preceded polytheism, and that the exhaustion of the latter prepared the minds of all genuine thinkers for the reception of a monotheism such as that of Christianity, 'which has persisted to the present time in giving partial satisfaction to the mental dispositions that lead to polytheism by admitting into its theology the thoroughly polytheistic conception of a devil.' This tendency to monotheism was the result of a practical feeling of the invariability of natural laws; but for many centuries the monotheistic creed so introduced

was belief in a God 'flexible by entreaty, incessantly ordering the affairs of mankind by direct volitions, and continually reversing the course of nature by miraculous interpositions.' Here, again, according to M. Comte, the influences which led to the decay of polytheism had a further field for action. The increased assurance of a natural order gradually excluded the idea of such interferences; and the metaphysical stage, which followed this exclusion, has given way or is yielding to the positive mode of regarding all phenomena in the one aspect of sequence or succession.

On these principles M. Comte undertook the Herculean task of arranging all sciences according to the degree of the complexity of their phenomena, so that each science shall depend on the truths of all those which precede it with the addition of peculiar truths of its own. But for further details of his plan and of the method in which he carried it out, and for a more complete examination of his philosophy in its earlier and later aspects, we must refer the reader to the elaborate articles in which Mr. J. S. Mill has analysed the merits and defects of M. Comte as a philosopher and a sociologist. (*Westminster Review*, April and July, 1865; these articles have since been republished.) On a subject so vast, and so encumbered with controversy, we have confined ourselves to giving, as nearly as possible, in Mr. Mill's words, a brief account of his primary doctrines, which may serve to give a true, although necessarily inadequate, idea of his system. We refer the reader also to an article entitled 'Comte and Positivism,' in *Macmillan's Magazine*, March 1866), in which Dr. Whewell maintains that the history of every science would reveal to us how baseless is the notion that there is a good positive stage of science which succeeds a bad metaphysical stage.

Posology (Gr. πόσος, *how much*; and λόγος, *description*). In Medicine, that which relates to the doses or quantities in which medicines should be administered.

Posse Comitatus (Lat. cum potestate comitatus). In Law, the power of the county, which the sheriff is empowered to raise in case of riot, possession kept on forcible entry, rescue, or other force made in opposition to the king's writ or execution of justice. It is said to include all knights and other men, above the age of fifteen, able to travel within the county. Justices of the peace may also raise the posse in order to remove a force in making entry into or detaining lands.

Post (Lat. positus, part. of pono, *I place*). In Public Economy, a messenger, courier, or conveyance travelling at stated periods, and generally with more than ordinary speed, to convey letters or other despatches, whether of government or individuals. [POST OFFICE.]

Post Mortem (Lat. *after death*). In Anatomy, the technical phrase signifying the inspection and examination of the dead body in order to determine the cause of death: it is also applied to the appearances presented, and more especially to some phenomena which are constantly noticed shortly after death. Thus, the muscles retain their property of contracting under the influence of stimuli applied to them, or to their nerves, for some time after death; and when they have lost this irritability, they spontaneously pass into a state of contraction, producing a general stiffening of the body, which is called *post-mortem rigidity*, or *rigor mortis*.

Post Obit (Lat. post obitum, *after death*). A bond given for the purpose of securing a sum of money on the death of some specified individual.

Post Office. A place for the reception and distribution of the letters and despatches that are to be or that have been carried by the post; where the duties on them are paid, and where the various departments connected with the business of the post are conducted or superintended.

The conveyance of letters by post is one of the few industrial undertakings which are certainly better managed by government than they could be by individuals. It is indispensable to the satisfactory working of the post office that it should be conducted with the greatest regularity and precision; and that all the departments should be made subservient to each other, and conducted on the same plan. It is plain that such results could not be obtained in any extensive country otherwise than by the agency of government; and the interference of the latter is also required to make arrangements for the safe and speedy conveyance of letters to, from, and through foreign countries.

The organisation of the post office supplies one of the most striking examples of the advantages resulting from the division and combinations of employment. 'Nearly the same exertions that are necessary to send a single letter from Falmouth to New York will suffice to send 50,000. If every man were to effect the transmission of his own correspondence, the whole life of an eminent merchant might be passed in travelling, without his being able to deliver all the letters which the post office forwards for him in a single evening. The labour of a few individuals, devoted exclusively to the forwarding of letters, produces results which all the exertions of all the inhabitants of Europe could not effect, each person acting independently.' (Senior *On Political Economy*.)

Posts appear to have been established for the first time in modern Europe in 1479, by Louis XI. of France. They were originally intended to serve merely for the conveyance of public despatches, and of persons travelling by authority of government. Subsequently, however, private individuals were allowed to avail themselves of this institution for forwarding letters and despatches; and governments, by imposing higher duties or rates of postage on the letters and parcels conveyed by post than are sufficient to defray the expense of the establishment, have rendered it productive of a

considerable revenue. Nor, while the rates of postage are confined within reasonable limits, and do not materially affect the facility of correspondence, is there, perhaps, a less objectionable tax.

The post office was not established in England till the seventeenth century. Postmasters, indeed, existed in more ancient times; but their business was confined to the furnishing of post horses to persons who were desirous of travelling expeditiously, and to the despatching of extraordinary packets upon special occasions. In 1635, Charles I. erected a letter office for England and Scotland; but this extended only to a few of the principal roads; the times of carriage were uncertain; and the postmasters on each road were required to furnish horses for the conveyance of the letters at the rate of 2½*d.* a mile. This establishment did not succeed; and, at the breaking out of the civil war, great difficulty was experienced in the forwarding of letters. At length a post office, or establishment for the weekly conveyance of letters to all parts of the kingdom, was instituted in 1649, by Mr. Edward Prideaux, attorney-general for the Commonwealth; the immediate consequence of which was a saving to the public of 7,000*l.* a year on account of postmasters. In 1657, the post office was established nearly on its present footing, and the rates of postage that were then fixed were continued till the reign of Queen Anne. (Black. *Com.* by Stephens, vol. ii. pp. 576–8.)

From the establishment of the post office by Cromwell, down to 1784, mails were conveyed either on horseback, or in carts made for the purpose; and instead of being the most expeditious and safest conveyance, the post had become, at the latter period, one of the slowest and most easily robbed of any in the country. In 1784, it was usual for the diligences between London and Bath to accomplish the journey in *seventeen* hours, while the post took *forty* hours; and on other roads the comparative rate of travelling of the post and stage coaches was in about the same proportion. The natural consequence of such a difference in point of despatch was, that a very great number of letters were sent by other conveyances than the mail: the law to the contrary being easily defeated, by giving them the form of small parcels.

Under these circumstances, it occurred to Mr. John Palmer, of Bath, comptroller-general of the post office, that a very great improvement might be made in the conveyance of letters, in respect of economy, as well as of speed and safety, by contracting with the proprietors of stage coaches for the carriage of the mail; the latter being bound to perform the journey in a specified time, and to take a guard with the mail for its protection. Mr. Palmer's plan encountered much opposition, but was at length carried into effect with the most advantageous results. The use of mail-coaches speedily extended to most parts of the empire; and, while letters and parcels were conveyed in less than half the time that had been required under the old system, the coaches by which they were conveyed afforded, by their regularity and speed, a most desirable mode of conveyance for travellers. Mr. Palmer was the author of several other improvements in the economy of the post office; nor is there any individual to whom the department owes more. (Macpherson's *Annals of Com.* anno 1784.)

Within the last few years, however, the construction of railways between most of the great towns of the empire has gone far to supersede the use of mail coaches on the principal lines of road, and has added prodigiously to the facilities of correspondence and travelling. The journey from London to Liverpool, which had been accomplished by the mail in about twenty or twenty-two hours, is now accomplished, by railway, in nine or ten hours; and on other roads in the same proportion. The great expense of the post office consists, in fact, not so much in the conveyance of letters from place to place, as in their previous collection and their distribution after they have been conveyed to their destination. This necessitates the establishment of a vast number of subordinate offices in the remoter parts of the kingdom, many of which do not defray their expenses. Much of this expense, however, has been obviated of late years by economy in the means of collection, especially by the establishment of pillar letter boxes in substitution for offices in town and village shops.

Up to 1839, the rates of postage levied on the carriage of letters were exceedingly high, amounting, it is said, to a fraction above 7*d.* on each letter. The post office was treated practically as a tax on private correspondence, for the monopoly of the post was cautiously guarded by penal clauses inflicting heavy fines on any person who made use of any method of transmitting letters besides that provided by government. These penal clauses were probably inoperative, or, if they had any operation, must have affected only the inexperienced and unwary. It is certain that, notwithstanding the great growth of foreign and home trade, the revenue of the post office remained almost stationary for twenty years; in other words, its provisions were evaded. Under such circumstances some remedial measure became absolutely necessary. This was discovered, or at least elaborated, by the secretary of the post office, Sir Rowland Hill, and the scheme suggested by him was, in its leading features at least, carried out by the government.

The fundamental principle of the new Post Office Act, was that the rate paid should be uniform, on the ground that the charge levied was not for carriage, this being in so light a matter as a letter unimportant, but for collection and distribution. The rate at which the service should be appraised was not, it appears, so essential a consideration; though it was felt that, on the whole, government, acting in the carriage of letters as a trader, should not seek to obtain an exorbitant rate of profit

for the service rendered. However, after a short period, during which the maximum rate was 4*d*., the uniform sum of 1*d*. was imposed, and the weight suffered to pass at this rate was fixed at half an ounce. Another feature in the new postal system was that of enforcing the prepayment of letters by levying a fine of one hundred per cent. as the postage on unpaid letters. The advantage of this regulation is obvious: it saves the labour of collection and distribution to a great extent. An attempt, indeed, was made to insist still more urgently on the necessity of prepayment, by issuing a regulation to the effect that unstamped letters would not be forwarded. We are not informed as to the amount of loss consequent upon the collection of double rates for unpaid letters; but when the above-mentioned regulation was issued, the opposition to it, due, as far as it can be interpreted, to selfish and sentimental motives, was so strong that the rule was withdrawn. Previous also to the new Post Office Act, members of parliament had the privilege of sending free a certain number of letters daily. The privilege was abused, no doubt. It was abolished by the Act, and no letters are sent free except petitions intended to be presented to the houses of parliament, and bearing evidence of their nature. Even the public offices, though they send official letters which are unstamped, and practically unpaid, are debited with the postage, the aggregate amount due from each office forming part of its annual expenses.

Many persons objected strongly, at the time of passing the new Act, to the rate at which the postage would be levied for the future. The most powerful argument brought forward by the objectors, was that of the loss likely to accrue to the revenue; and it cannot be denied that the prediction was verified, the office having only lately returned annual profits equal to those obtained before the alteration was made. But the moral advantages of a cheap postal system are far more important than the mere question of the revenue derived from the post office; and beyond question the commercial benefits which have ensued from providing the means of cheap and ready communications have helped the revenue indirectly by returns infinitely in excess of that which could have been obtained under the old system. Any tax on correspondence is a great bar to exchange, a serious hindrance to trade, and therefore a damage to the gross revenue derivable, as all revenue must be, from the profits of production and commerce. It is true that as long as the profit is in excess of the charge at which letters are collected and delivered, the rate is of the nature of a tax; but as long, on the other hand, as the government system provides means of communication at a rate lower than that at which joint-stock enterprise could do the same service, it is a gain to the public, and in so far as it represents a profit upon the capital employed in the labour, it is an advantageous method by which a nation trades on its own account. Nor is it to the purpose to compare the taxation of the old system, with a tax upon any convenience of life, as sugar or tea. Once paid, the taxes levied on such commodities as these have ceased to have any effect. But a heavy tax levied upon an act necessary for the purposes of trade produces far more loss than its first and immediate incidence. It hampers and hinders other operations, and in effect does what the worst tax does—costs a community far more than it gets for the revenue.

The post office has extended its operations in certain directions unknown and indeed impossible under the old régime, but now of great advantage to the nation, and in some cases of great profit to the government. First, it acts as a common carrier in the transmission of books and papers at low rates. The system of taxing newspapers was to some extent compensated by their exemption from the old postage rates. This, which was originally a mere act of reciprocity, has been since the reduction and ultimately the abolition of the stamp duty, continued on payment of the lowest stamp rate, or, supposing the newspaper to be below a certain weight, on a prepayment by a penny stamp. The advantage accorded to newspapers has since been on reasonable grounds extended to all printed matter and such writing as is not of the nature of a letter. Next, it has afforded a means by which additional security is afforded to letters of value. The post office has never been liable to the law of bailment, i.e. to the conditions attached to the function of a common carrier of compensating the owner of property intrusted to such a person for loss, damage, or delay. There are, indeed, obvious reasons why a government office should be exempted from such a general liability. By means of registration, however, a security is afforded to valuable letters and enclosures which is practically equal to the provisions of the law of bailments in the case of a common carrier. Thirdly, by means of post office orders the government has taken upon itself some of the functions of a bank. The rates at which this service is rendered are still probably too high, and amount in the transmission of small sums to a very heavy percentage, falling with undue weight on such of the poorer classes as are likely to transmit these small amounts. But, on the whole, the adoption of the government orders is of great public utility. And, lastly, it has been made the channel by which government has given the advantages of savings-banks at a moderate rate of interest, and with absolute security, to the public. This last scheme is only in its infancy; but it is very likely that hereafter it may be a very important means for dealing with a considerable portion of the public debt.

The postal system in this country has been, to a small extent, imitated by foreign governments. They have, for instance, all adopted stamps, and this even in the most remote regions. But very few of these communities have

adopted a rational postal system, or taken anything more than the superficial features of the English method. The arrangements, too, for the simplification and economy of international posts, are far from complete; and the difficulties put in the way of such arrangements as would facilitate communications between the inhabitants of various countries, are part of the barbarism which still attaches to modern administrations. Some progress, however, has been made, and more no doubt will be made, as communities learn to apprehend more clearly their real and abiding interests. In short, Sir Rowland Hill is one of the few fortunate persons who, having initiated a great reform, has not only lived to see it generally adopted, but has had the rarer satisfaction of seeing it generally approved by all enlightened and sensible persons.

Of late years a demand has been made for the reduction of postages between this country and others, especially between Great Britain to and from the colonies and the United States. Considering the importance of the trade between this country and those regions, and taking also into account that they are of the same origin with ourselves, and have very similar political, social, and even domestic interests, it seems to be a matter of the highest policy that communications between Great Britain and the Anglo-Saxon races should be facilitated to the greatest extent possible. We may repeat, that the gain and loss to the revenue in the establishment of ready means for commercial and social intercourse by no means represent the true gain accruing to the administration in the extension of trade, and to the communities themselves in the growth of mutual knowledge, intimacy, and kindly feeling.

Postage stamps perform, to a very large extent, the office of a minor form of paper currency in this country. They are not a legal tender: it may be doubted whether the transfer and sale of postage stamps, which is in effect the meaning of their use as currency, be not a violation of the stamp laws; but it is almost needless to observe, that public convenience is rarely hindered by such an innocent breach of fiscal regulations. In the United States, during the late civil war, postage stamps were made a legal tender for sums below a certain amount, and were, on the same principle and with similar limitations, receivable in payment of taxes. It is, perhaps, impossible at present to interpret the political and fiscal necessities which led to the Legal Tender Act of Congress; it is well known that a state paper currency has been a favourite expedient with the United States' government, and it is entirely premature to predict the period at which the resumption of cash payments will be made, and the injury inflicted on the recipients of fixed incomes by the Legal Tender Act redressed. It is quite clear, however, that the mischief of a forced paper is always proportioned in extent to the lowness of the denomination which is thus put into circulation.

Post Position. In Music, a retardation of the harmony, effected by placing discords upon the accented parts of a bar not prepared and resolved according to the rule for discords.

Posts. In Military operations in the field, *advanced posts* are placed at a distance from the main body. These for their own safety push forward *outposts*, which are supported by strong *pickets*. *Patrols* keep up the communication.

Post-abdomen. The name applied by Latreille to the five posterior segments of the abdomen of Hexapod insects; and to the tail of Crustaceans, which consists of homologous but more numerous segments.

Postage. The rate of charge levied on letters or other articles conveyed by post. [POST OFFICE.]

Postea (Lat.). In Law, the return of the judge before whom a cause is tried, after verdict, of what was done in the cause, which is endorsed on the back of the nisi prius record.

Postern (Fr. posterne, now written pôterne, Ital. postierla, Low Lat. posterula). In Architecture, a small door, or gate, at the back of a building.

POSTERN. In Fortification, a vaulted passage underneath a rampart, leading from the interior into the ditch, and closed by a gate.

Postill (said to be from Lat. post illa, *after them*). A title sometimes given in ecclesiastical language to a homily or sermon delivered *after* and upon a lesson or text taken from Scripture.

Postliminium or **Jus Postliminii** (Lat.). In National and Civil Law, the right by virtue of which persons taken in war return to their former state of freedom, with their former rights and property, on its termination; and property so taken reverts to its former owners.

In the middle ages the term also denoted the process by which a citizen, going to a foreign country, claimed for himself the rights of a subject and citizen of the land which he was leaving, so that on his return he was reinstated at once into his former condition.

Postscenium (Lat.). In Architecture, the back part of the theatre behind the scene, furnished with conveniences for robing the actors, and depositing the machinery.

Postulate (Lat. postulatus, part. of postulare, *to demand*). In Geometry and Logic, something to be assumed, or taken for granted. Euclid has constructed his *Elements* on the three following postulates: 1. That a straight line may be drawn from any one point to any other point. 2. That a terminated straight line may be produced to any length in a straight line. 3. That a circle may be described from any centre at any distance from that centre. (Playfair's *Euclid*.)

Pot Metal. An alloy of copper and lead. The term is also sometimes applied to glass as it comes from the glass-pots.

Potash. The saline matter obtained by lixiviating the ashes of wood. When purified by calcination it is termed *pearlash*, and is in that

state an impure *carbonate of potassa*. The production of potash is carried on upon a large scale in Russia and America; it can be thus obtained only in countries where there are vast natural forests, and where the value of timber is little more than that of the labour of felling it. [POTASSIUM.]

Potassa. [POTASSIUM.]

Potassium. This metal, represented by the symbol K, *kalium*, was discovered by Davy in the year 1807, and was one of the first fruits of his electro-chemical researches. Its properties were so remarkable, that it was for a time doubted whether it could with propriety be placed among the metals; but the progress of discovery removed all difficulty upon that point, by making us acquainted with other metallic substances with properties intermediate between those of potassium on the one hand, and the common metals on the other. The specific gravity of potassium is ·865 at the temperature of 60°; it is solid at the ordinary temperature of the atmosphere; at 80° it becomes soft, and at 150° is liquid; at 32° it is brittle, and has a crystalline texture. In colour and lustre it much resembles mercury. Its affinity for oxygen is such that it immediately loses its brilliancy on exposure to air; when heated in the air, it burns with a purple flame. The equivalent of potassium is 39, and that of *protoxide of potassium* is 47. When potassium is heated in oxygen it absorbs a larger quantity of that element and becomes a *peroxide*, which, however, is immediately converted into protoxide by the action of water. Protoxide of potassium exists in the state of *hydrate* in what is called *caustic potash*, which is a compound of ·47 potassa + 9 water. This substance fuses below a dull red heat; it is very soluble and deliquescent, and acts powerfully on almost all animal textures. It is the *lapis causticus* of old pharmacy. Dissolved in water, it forms *soap ley*, or the *liquor potassæ* of the *Pharmacopœia*. This solution is obtained by pouring water upon a mixture of equal parts of quicklime and carbonate of potassa; the lime abstracts carbonic acid from the carbonate, and becomes converted into an insoluble carbonate of lime, whilst the evolved potassa is taken up by the water. This solution is powerfully alkaline, and soon absorbs carbonic acid when exposed to air. Free potassa is recognised, when in solution, by its alkaline reaction upon test-paper, and it is distinguished from soda by adding to it excess of tartaric acid, when it yields a white granular precipitate of bitartrate of potassa. When potassa is in combination, as, for instance, when its salts are dissolved in water, they are detected, if the solution be not too dilute, by a strong solution of chloride of platinum, which causes a yellow precipitate of potassio-chloride of platinum.

When potassium and sulphur are heated together, they combine and form a sulphuret of potassium. With the acids potassa forms a variety of useful salts; such as nitre, or nitrate of potassa, with nitric acid; sulphate of potassa with the sulphuric acid; and carbonate of potassa with the carbonic acid. The latter is a very important salt; it forms the greater part of the residuum or ash of burnt wood, from which it is obtained by lixiviation. It is brought to this country from Russia and America, under the names of *pearlash* and *potash*, and consists of 47 potassa + 22 carbonic acid; it is deliquescent, and has an alkaline reaction. When carbonic acid is passed through a solution of this salt, it becomes converted into bicarbonate of potassa, composed of 47 potassa + 44 carbonic acid. Potassium burns with great splendour in chlorine, and forms chloride of potassium; it also combines with iodine, bromine, and fluorine, and with many of the metals.

Potato. The common name for the tubers of the *Solanum tuberosum*.

Potato Disease. This formidable malady, which first appeared in Great Britain in 1845, and is marked by the rapid putrescence of the leaves and haulm of the Potato plant, is now referred, and apparently with good reason, to the attack of a little fungus or mould called *Peronospora infestans*, which preys upon the tissues, spreading rapidly in every direction, so that the tubers become affected with brown spots both on their surface and within their tissue, and decay with greater or less rapidity. The mould would appear to be the primary cause; but as it attacks the tissues before it appears externally, it is almost impossible to apply a remedy. The two most important plans which have been adopted, though far from infallible, are the powdering of the sets with flowers of sulphur, and early planting The removal of the haulm as soon as the mould appears has also been found beneficial. The disease has been equally bad in the wettest and hottest seasons, and was in many districts as virulent in 1860 as on its first appearance, the worst year perhaps being 1846, when its sudden inroad produced a fearful famine in Ireland, which resulted in the death of thousands of the population, and led to the repeal of the corn laws.

German authors distinguish two forms, the wet and dry rot. It is, however, to be observed that these diseases, which are characterised not only by the peculiar condition of the tubers, but by the presence of *Fusisporium Solani tuberosi*, were prevalent in this country before 1845. The brown mottled appearance of the tubers, and the presence of *Peronospora* on the leaves and the exposed tissues, was previously unknown. (Berkeley, *Treasury of Botany*.)

Potency of a Point. The potency of a point, with respect to a circle, is the rectangle under the segments into which that point divides any chord of the circle which passes through it. The potency is clearly the square of half the shortest chord through the point, when the latter is within the circle, and the square on the tangent, when the point is without the circle. The term *potenz*, of which *potency* is Prof. Cayley's translation, was introduced by Steiner. (Crelle's *Journal*, vol. i.) The points of equal potency with respect to two circles lie in a right line, called by Steiner

the *line of equal potency*, by Magnus the *axis of collineation*, by Plücker the *chordale*, and by Gaultier the *radical axis*. The last name is the one now generally used. [RADICAL AXIS.]

Potential. In the Calculus of Attraction, the potential of a body, or system of bodies, relatively to a given point M, whose rectangular coordinates are x, y, z, is a certain function of these coordinates whose three first partial differential coefficients give, to a constant factor près, the three components of attraction or repulsion on a material particle placed at M. When the law of attraction is that of the inverse square of the distance, the potential may be defined as the sum of each mass-element of the attracting body divided by the distance of that element from the attracted point. It is expressed, therefore, by

$$V=\int\frac{dm}{r},$$

where the integration is to be extended to all the elements of the body. Calling R the resultant attraction on a material particle of the mass μ, situated at M (x, y, z), and X, Y, Z the components of attraction in the directions of the coordinate axes, we have

$$X=-\mu\frac{dV}{dx},\ Y=-\mu\frac{dV}{dy},\ Z=-\mu\frac{dV}{dz},$$

and hence

$$\frac{R}{\mu}=-\sqrt{\left(\frac{dV}{dx}\right)^2+\left(\frac{dV}{dy}\right)^2+\left(\frac{dV}{dz}\right)^2}.$$

An important property of the potential is expressed by the following differential equation:

$$\frac{d^2V}{dx^2}+\frac{d^2V}{dy^2}+\frac{d^2V}{dz^2}=-4\pi\rho,$$

where ρ represents the density of the attracting body *immediately around* the attracted point. When the latter is external to the attracting mass, therefore, the above sum vanishes, as was first shown by Laplace. In the above more general form the equation is due to Poisson.

The points relatively to which the potential has the same value, lie on the so-called *equipontial* or *equilibrium surface*, which is everywhere normal to the direction of the resultant, i.e. to the *lines of force*.

Legendre, Lagrange, Laplace, Poisson, and Gauss, were among the first to introduce the potential into mechanical investigations. The name, however, was originated by George Green, whose *Essay on the Application of the Mathematical Analysis to the Theories of Electricity and Magnetism*, Nottingham 1828 (reprinted in vols. xliv. and xlvii. of Crelle's *Journal*), together with Gauss' *Memoir on General Theorems relating to Attractive and Repulsive Forces varying inversely as the Square of the Distance* (*Result aus den Beob. des mag. Vereins*, Leipzig 1840, translated in Taylor's *Scientific Memoirs* 1842, and in Liouville's *Journal* 1842), are classic works on the subject. Chasles, too, has written several geometrical papers treating of the same matter; one of these will be found in the *Connaissance des Temps* for 1845. The works of Dirichlet, when collected, will probably contain the far-famed lectures on the calculus of attraction, delivered by him periodically at the university of Berlin, wherein the properties of the potential are fully developed.

Potential Energy. In Mechanics, a bent spring, a raised weight, or compressed air, &c. is said to possess *potential energy*, because it is in a condition to do work if allowed. Potential energy is measured by the work done in bringing the body to the condition in question. It is an important theorem in modern science that in a system of bodies, subjected solely to mutual actions, *the sum of potential and actual energy* (*vis viva*) *is always constant*. (Helmholtz *On the Conservation of Force*, Berlin 1847, and *Scientific Memoirs*, 1853; Rankine in *Phil. Mag.* 1853 and *Edin. Phil. Journ.* 1855; Tait and Steele's *Dynamics of a Particle*, &c.)

Potential Mood (Lat. potentia, *power*). In Grammar, that mood of the verb which expresses an action conceived as *possible*; denoted in English by the auxiliary verb *may* or *might*.

Potential Qualities. In Scholastic Philosophy, such qualities as are supposed to exist in a body *in potentia* only.

Potentilla (Lat. potens, *powerful*). A very showy genus of garden flowers, yielding numerous hardy herbaceous perennials of an ornamental character. It also contains several native species, mostly of a weedy aspect. The genus belongs to the *Rosaceæ*, and somewhat resembles the strawberry, to which it is allied.

Poterium (Lat.; Gr. ποτήριον, *a drinking cup*). A native English plant, the leaves of which resemble the fruit of the cucumber in flavour. It is, however, an agrarian weed, often troublesome in crops of saintfoin, and probably in such cases attributable to mixed or foul seed having been sown.

Potitii. Roman priests of Hercules, said to have been appointed by Evander. The myth of Hercules and Cacus furnishes the institutional legend. The two families of the Potitii and Pinarii performed the rites of Hercules about the ara maxima, the former being admitted to the feast while the latter were only allowed to minister at the sacrifice; or, according to another version, the Potitii were regaled on the entrails of the ox, the Pinarii being confined to the other parts of the animal. According to others, the word *potitii* had reference to the privilege of that family, the name *pinarii* being connected with the Greek πεινᾶν, *to hunger*, because they came too late for the banquet. Later legends said that Appius Claudius, when censor, induced the Potitii to transfer their functions to public slaves, whereupon the families of the gens Potitia died within the year, or, according to another account, within thirty days. (Sir G. C. Lewis, *Credibility of Early Roman History* i. 293.)

Potstone. A coarsely granular variety of Steatite or Soapstone, which on account of its tenacity, infusibility, and the ease with which it may be turned in the lathe, is frequently made into culinary vessels, especially in Italy, Corsica, Germany, France, and the island of Sark.

Pottery and Porcelain. The better kind of pottery, called in this country *Staffordshire ware*, is made of an artifical mixture of alumina and silica; the former obtained in the shape of a fine clay, chiefly from Devonshire and Dorsetshire; and the latter consisting of chert or flint, which is heated red-hot, quenched in water, and then reduced to powder. Each material, carefully powdered and sifted, is diffused through water, mixed by measure, and brought to a due consistency by evaporation: it is then highly plastic, and formed upon the potter's wheel and lathe into various circular vessels, or moulded into other forms, which, after having been dried in a warm room, are enclosed in baked clay cases resembling bandboxes, and called *seggars*; these are ranged in the kiln so as nearly to fill it, leaving only space enough for the fuel; here the ware is kept red-hot for a considerable time, and thus brought to the state of *biscuit*. This is afterwards glazed, which is done by dipping the biscuit-ware into a tub containing a mixture of about 60 parts of litharge, 10 of clay, and 20 of ground flint, diffused in water to a creamy consistence; and when taken out, enough adheres to the piece to give a uniform glazing when again heated. The pieces are then again packed up in the seggars, with small bits of pottery interposed between each, and fired in a kiln as before. The glazing mixture fuses at a comparatively moderate heat, and gives a uniform glossy coating, which finishes the process when it is intended for common white ware.

The patterns upon ordinary porcelain, which are chiefly in blue, from the facility of applying oxide of cobalt, are generally first printed off upon paper, which is attached to the plate or other article while in the state of biscuit; the colour adheres permanently to the surface when heat is properly applied: other mineral colours, such as the oxides of chromium and manganese, are also occasionally employed in the same way.

The manufacture of PORCELAIN is a more refined branch of art; the materials are selected with the greatest caution, it being necessary that the compound should remain perfectly white after exposure to heat: it should also endure a very high temperature without fusing, and at the same time acquire a semi-vitreous texture, and a peculiar degree of translucency and toughness. These qualities are united in some of the Oriental porcelain, or *China*, and in some of the old Dresden; but they are rarely found coexistent in that of modern European manufacture. Some of the French and English porcelain, especially that made at Sèvres and Worcester, is extremely white, and duly translucent; but it is more apt to crack by sudden changes of temperature; more brittle, and consequently requires to be formed into thicker and heavier vessels; and more fusible than the finest porcelains of Japan and China.

The colours employed in painting porcelain are the same metallic oxides used for colouring glass, and in all the more delicate patterns they are laid on with a camel's hair pencil, and generally previously mixed with a little oil of turpentine. Where several colours are used, they often require various temperatures for their perfection; in this case those that bear the highest heat are first applied, and subsequently those which are brought out at lower temperatures. This art of painting on porcelain, or *in enamel*, is very delicate: much experience and skill are required in it, and with every care there are frequent failures; hence it is attended with considerable expense. The gilding of porcelain is generally performed by applying finely divided gold mixed with gum-water and borax; upon the application of heat the gum burns off, and the borax vitrifying upon the surface causes the gold firmly to adhere: it is afterwards burnished.

In the manufacture of various kinds of pottery employed in the chemical laboratory, and especially in regard to *crucibles*, many difficulties occur; and many requisites are necessary, which cannot be united in the same vessel. To the late Mr. Wedgwood we are indebted for vast improvements in this as well as in other branches of the art. Crucibles composed of one part of pure clay mixed with about three parts of coarse and pure sand, slowly dried and annealed, resist a very high temperature without fusion, and generally retain metallic substances; but where the metals are suffered to oxidise, there are few which do not act upon any earthen vessel, and some cause its rapid fusion, as the oxides of lead, bismuth, &c. Where saline fluxes are used, the best crucibles will always suffer; but platinum may often be employed in these cases, and the chemist is thus enabled to combat many difficulties which were nearly insurmountable before this metal was thus applied. Whenever silica and alumina are blended, as in the mixture of clay and sand, the compound softens, and the vessel loses its shape when exposed to a long-continued white heat, and this is the case with the *Hessian* crucibles: consequently, the most refractory of all vessels are those made entirely of clay, coarsely powdered burnt clay being used as a substitute for the sand. Such a compound resists the action of saline fluxes longer than any other, and is therefore used for the pots in glass furnaces. A Hessian crucible lined with purer clay is rendered much more retentive; and a thin china cup, or other dense porcelain, resists the action of saline matters in fusion for a considerable time. Plumbago is a very good material for crucibles, and applicable to many purposes; when mixed with clay it forms a compound not easily fusible, and is protected from the action of the air at high temperatures: it is well calculated for small table furnaces. [EARTHENWARE; GLASS.]

Pouch (Fr. poche). In Military equipment, a leather case, lined with tin, to carry a soldier's ammunition.

Poudrette (Fr.). A manure composed of night soil mixed up with clay, dried and formed into cakes.

Poulp (Fr. poulpe). The generic name of the eight-footed dibranchiate Cephalopods (*Octopi*), which have a double alternate row of suckers on each foot.

Poultry (Fr. poule, Lat. pullus, Gr. πῶλος, the *foal* or young of animals). Different kinds of birds reared for the production of eggs and feathers, and for the use of their bodies as animal food. The domestic poultry in common use in Britain are the common domestic fowls, or cock and hen, the turkey, the duck, and the goose; to which may be added, as occasionally reared, the guinea fowl and the peacock. The most generally useful kind of poultry is the common domestic fowl, which, though a native of India, accompanies man through all climates, but which produces an abundance of eggs only when well fed and warmly lodged. All poultry houses, therefore, when not built adjoining an apartment in which fire is kept, or over a stable or cowhouse, where they may benefit by the heat generated by the larger animals, ought to be furnished with flues, or some other means of generating heat artificially during winter and spring. Without some mode of effecting this, poultry will seldom yield a good supply of eggs in cold weather, particularly in the colder parts of Britain. On this account, in Scotland, the common hen is allowed to roost in the same room in which the cottager lives; and the poultry-house of the small farmer is a loft either over his kitchen, or over his cow-house. In the management of poultry it is essential that they should have not only the necessary food and warmth, but also ample space for exercise. This space should always contain living plants of various kinds, and some gravelly, calcareous, or sandy soil; because worms, snails, and insects, as well as grass and herbage occasionally, form a part of the food of poultry; and sand or gravel is swallowed by them for the purpose of promoting digestion. Hence, no healthy poultry can ever be reared in towns, however much the natural food may be imitated by the supply of animal matters, herbage, and sand: the want of exercise in poultry so circumstanced will soon become evident from the appearance of the fowls, and from the soft shell of their eggs.

Some breeds seem, however, to require less liberty than others. We add a list of the breeds now known and cultivated in this country.—*Grey, Silver Grey, Speckled, and White Dorkings*—Excellent farmyard fowls. Good layers and sitters. Very good mothers. Not calculated for confinement. Unequalled as a table or market fowl. Very large. *Brahma Pootra*—Excellent layer, perfect sitter, and mother; so hardy it may be hatched and reared in any weather. Two varieties: one pencilled; the other white, with black flight and tail, and striped hackle. These birds bear any confinement. As winter layers the Brahma Pootras excel all other birds. *Spanish*—Very handsome black birds. Lay larger eggs than any other breed, and in great numbers. Thrive in any locality, however confined. Do not sit. Their colour suited for any atmosphere. *Cochin Chinese*—Seem to prefer a very limited space; capital layers; very hardy; seldom or never out of condition. Good sitters. Chickens very easily reared. Pullets hatched in spring are good winter layers. *Crevecœurs*—Hardy birds, and most profitable layers, producing an unusual number of very large eggs during the autumn when most birds are deep in moult. They are excellent table birds, do not sit, and thrive well in stable yards, small homesteads, and confined places. *La Flèche*—The finest fowl known in France, a very handsome upstanding bird of jet black plumage; the comb is in the form of two upright horns. A delicious table fowl of great size; an excellent layer. Thrives well on a good run, or farm yard. *Game*—Hardy and capital birds. Good layers, good mothers, excellent for the table. Will do well in confinement. Suited to every soil and climate. Varieties: Black and Brown-breasted Reds, Duck-wings, Black, White and Piles. *Hamburgs*—Very handsome birds, unusually good layers, bear moderate confinement well. Do not sit. *Polands*—Remarkably handsome birds, very good layers, but non-sitters. Fit for the paddock, but not for confinement. Varieties: Golden and Silver Spangled, and Black with white top-knots. *Houdans*—A recent introduction from France, where they are considered a very good table fowl. They are large, of a speckled colour, with top-knots. *Malay*—Hardy and prolific birds, will do well where all others fail; good layers, and well adapted for towns.

Poultry-houses. Structures in which poultry are kept in the night time; they should be so arranged that each kind of bird shall be separately lodged, and that all shall have access to an ample field, containing a pond and a heap of gravel. [POULTRY.]

Pounce (Fr. ponce, from Ital. pomice, Lat. pumex, *a pumice stone*: Wedgwood). A powder to prevent ink from spreading upon paper, after erasures: it is either sandarach (resin of the juniper) in powder, or the powdered bone of the cuttle-fish. The term *pounce* is also applied to coloured powders used by pattern drawers for sprinkling over pricked papers.

Pound (Ger. pfund; Lat. pondo, *in weight*). A measure of weight. In England two different pounds are used; the *pound avoirdupois*, and the *pound troy*. The pound avoirdupois weighs 7,000 grains troy, and the pound troy 5,760 grains. The former is divided into 16 ounces, and the latter into 12. [WEIGHT.] Pound is also a denomination of money; the pound sterling being equal in value to 20 shillings, or 240 pence. Anciently 240 pence were equivalent to a pound of silver; hence the origin of the term.

Poundage. An ancient ad valorem duty of five per cent., payable on all foreign goods imported into the kingdom, and occasionally on exports. It has been held that these duties were paid, time out of mind, on the plea that the king was by these means compensated for the cost of keeping up harbours and havens, and of defending merchants from pirates, and that the payment is part of the common law. This tax is, however, known to have had its origin in an Act of the first Parliament of Edward I. Poundage was at first granted for a limited period, then for the life of the king, generally among the Acts of the monarch's first parliament. The parliaments of Charles I. refused to make the grant, but those of his three legal successors were more complaisant. The need of providing larger means for the public service led the parliaments of Anne to mortgage this custom for the payment of the public debt, and poundage has been lost in the general imposition of customs duties.

Poupart's Ligament. The tendinous attachment of the external oblique muscle of the abdomen to the superior and anterior spinous process of the os ilium and os pubis.

Pourpoint (Fr.). In ancient armour, the quilted coat, worn next the body, otherwise often known as the gambeson or doublet. Sometimes an outer pourpoint was worn between the surcoat and the body armour.

Pourpresture or **Purpresture.** In Law, an ancient term to denote anything done to the injury of the king's tenants, by way of nuisance or hurt to the king's highways or demesnes, by enclosing, &c. Pourpresture may also be by tenant against lord of the fee, or by one neighbour against another.

Poursuivant. [PURSUIVANT.]

Powder Hose. A tube of strong linen, about an inch in diameter, filled with powder, and used for firing military mines.

Power. In Algebra, this word denotes the product arising from the continued multiplication of equal numbers or quantities. Thus a, aa, aaa, which for brevity are written a, a^2, a^3, denote respectively the first, second, and third powers of a. The small numbers in the above abbreviated expressions are termed the *indices* or *exponents* of the several powers. Powers of the same quantity are multiplied by adding, and divided by subtracting their exponents. Assuming the relation $a^m a^n = a^{m+n}$ to hold for all values of m and n, we are led to the conception of *negative* and *fractional powers*. The first are the reciprocals of the corresponding positive powers, thus $a^{-2} = \frac{1}{a^2}$; and the second are roots of powers or powers of roots; thus $a^{\frac{2}{3}} = \sqrt[3]{a^2} = (\sqrt[3]{a})^2$. Since $a^m a^0 = a^{m+0} = a^m$, we learn that a^0 must be regarded as a general symbol for unity whatever value a may have.

POWER. In Law, an authority given to a person enabling him to do some act with respect to property of which he is not the owner or not the absolute owner. Thus, for example, in an ordinary strict settlement of real property, it is usual to insert powers for the tenant for life to grant leases and to give a jointure to his wife or portions for his children, and for trustees to sell the property, or manage it during minorities and the like; and corresponding powers of investment, of appointing funds to particular children, of advancement and maintenance of minors, &c., are usually inserted in settlements of personal property. Again, in a mortgage the mortgagee has usually a power of sale to enable him to realise his security. Powers for the most part are strictly construed, and the courts are very vigilant in preventing their use for any purpose but that for which in the particular case they were intended; as, for instance, if a man having a power to appoint a fund among his children appoints it to one of them upon an understanding that he himself is to derive some private advantage, the appointment will be bad. There are many technical divisions of powers as they arise at common law, or under the Statute of Uses or some other statute, or are mere equitable authorities, affecting property vested in trustees or mortgagees, and the learning with respect to them forms one of the principal branches of Property Law. The introduction of lengthy powers is one of the principal causes of the bulk of English legal instruments, but this again arises from the great unwillingness always shown by the courts to extend by implication the authority over property of one not absolute owner of it to any cases not expressly provided for, so that it becomes necessary to provide by an appropriate clause for every occasion which is considered at all likely to arise. Some efforts have been recently made by the legislature (stats. 19 & 20 Vict. c. 120, 23 & 24 Vict. c. 145, &c.) to provide that certain powers should in specified cases be implied as of course.

POWER. In Mechanics, this term denotes a force which being applied to a machine tends to produce motion. A *mechanical power* denotes one of the six simple machines; viz. the *lever*, the *inclined plane*, the *screw*, the *wheel and axle*, the *wedge*, and the *pulley*.

Power of Attorney. In Law, an instrument by which a party empowers another to perform certain acts for him, either generally, or for a particular purpose; such as to accept and negotiate letters of exchange, to receive dividends, &c. An instrument by which a party authorises his attorney to appear and plead for him is termed a WARRANT OF ATTORNEY.

Powers, Great, of Europe. In the language of modern diplomacy, Great Britain, France, Austria, Russia, and Prussia, are so called.

Power-loom. [WEAVING.]

Poyning's Law, otherwise called the **Statute of Drogheda.** An enactment of the Irish parliament in 1495. It contains a variety of provisions to restrain the lawlessness of the Anglo-Irish within the pale (for to no others could it immediately extend), and to confirm the royal sovereignty. The article by which it is

principally known provided that no parliament should in future be holden in Ireland till the king's lieutenant had certified to the king under the great seal the causes and considerations, and all such acts as ought to be passed thereon, and such be affirmed by the king and his council, and his license to hold a parliament be obtained. Any parliament holden contrary to this form and provision should be deemed void. Thus by securing the initiative power to the English council, a bridle was placed in the mouth of every Irish parliament. (Hallam.) A practice, however, grew up afterwards of framing bills in either house of the Irish parliament under the denomination of *heads for a bill or bills*, by which the provisions of Poyning's law were in some measure evaded. (Goldwin Smith, *Irish History and Character*.)

Pozzuolana. Fine volcanic ashes mixed with about one fifth part of oxide of iron and a little lime form a natural hydraulic cement, which hardens under water and answers the purpose of Roman cement. It is much used in Italy instead of mortar, and has received its name owing to the fact of its being shipped from Pozzuoli. [CEMENTS; MORTAR.]

Praam. A sort of lighter used in Holland and the Baltic.

Practical Geology. [ECONOMIC GEOLOGY.]

Practice (Fr. pratique, Span. practica, from Gr. πρακτικός). A rule in Arithmetic for expeditiously solving questions in proportion; or, rather, for abridging the operation of multiplying quantities expressed in different denominations, as pounds, shillings, and pence; yards, feet, and inches, &c.

Præcordia (Lat. from præ, and cor, *the heart*). The fore part of the chest.

Præfect (Lat. præfectus). The title of several Roman functionaries. Of these the most important were: (1) præfectus urbi, the præfect or warden of the city, originally called Custos Urbis. This officer possessed the imperium in the city during the absence of the consuls; but the institution of the office of prætor urbanus left no room for his functions. The conservative spirit of the Romans, however, still induced them to appoint a præfectus urbi for the time during which the consuls were absent from Rome to celebrate the feriæ Latinæ; but this officer had no right of convoking or of speaking in the senate, and it became a nominal distinction conferred on young men of illustrious families. The office to which Augustus appointed Mæcenas was very different from this, being a regular and permanent magistracy invested with all necessary powers for maintaining peace and order in the city. Under this præfect was a force of milites stationarii, or city police; and the powers of the office were gradually so far extended that at last there was no appeal from his sentence except to the princeps himself, whereas the præfectus urbi was empowered to hear appeals against any other city magistrates, and even against the governors of provinces. (2) The prætorian præfect, præfectus prætorio, commanded the PRÆTORIAN COHORTS. This officer, after the appointment of Sejanus by Tiberius, stood to the emperors in a relation not unlike that of the magister equitum to the DICTATOR, or of a Turkish vizir to the sultan. This office was not always held by military men, Ulpian, Papinian, and other lawyers having been numbered among the prætorian præfects. (3) The office of præfectus annonæ, or præfect of the provinces, was an extraordinary magistracy, filled only during times of scarcity. But after the fall of the republic, Augustus made the office permanent. In addition to these there were (4) the præfectus aquarum, an officer charged with the regulation of the water supply for the city; (5) the præfectus ærarii [ÆRARIUM], and (6) the præfectus vigilum, or commander of the Roman night-watch; with some others.

The title of præfect was also given to the governor of Egypt, the governors of the other imperial provinces being called legati Cæsaris, selected either from persons who had been consuls or prætors, or from the senators, while the governor of Egypt was of equestrian rank.

Præfloration (Lat. præfloreo, *to blossom before the time*). In Botany, the arrangement of the parts of the flower before expansion.

Præfoliation (Lat. præ, *before*; folium, *a leaf*). In Botany, the arrangement of the leaves in a leaf-bud.

Præmolar (Lat. præ, *before*, and molaris, *grinding tooth*). In Anatomy, the name of those permanent teeth in the Diphyodont mammals that displace and succeed the deciduous teeth vertically: they are situated before the molars; and, being in many cases of more simple structure, they have been termed *false molars*, and in Human Anatomy *bicuspides*. The præmolars never exceed four in number on each side of both jaws.

Præmonstratensians. [PREMONSTRATENSIANS.]

Præmorse (Lat. præmorsus, part. of præmordeo, *to bite*). In Botany, a term applied to parts which terminate abruptly in a rugged irregular manner, as if bitten off.

Præmunire. In Law, a name given to a species of offence, in the nature of a contempt, against the king and his government. The name is derived from the words *præmoneri*, or *præmuniri facias*, which are used in the begining of the writ preparatory to the prosecution of the offence: 'Cause A. B. to be forewarned that he appear before us,' &c. The first statute of præmunire was passed in the reign of Edward I. to restrain the encroachments of the Romish clergy: and several subsequent statutes before the Reformation have extended the number of penal acts under this title. By still later statutes, acts of a very miscellaneous character have been rendered liable to the penalties of præmunire, as a refusal to take the oaths of allegiance and supremacy, &c.

Prænomen. [COGNOMEN; NAME.]

Præraphaelite. In Painting, an illogical term lately introduced to signify a modern revival, with certain modifications, of the highly finished but crude and tasteless sentimental art of the fifteenth century, before the time of Raphael; an art which is characterised more by its defects than by its perfections. Its character is referred to in the Italian expression QUATTROCENTISMO.

Prætexta. [TOGA.]

Prætor. The Roman consuls were originally known by this name (Cic. *De Leg.* iii. 3), which simply signified priority. According to Livy, the office specially distinguished by this name was instituted B.C. 366, when, after the Licinian Rogations, L. Sextius had been elected the first plebeian consul. The patres refused to ratify his election, unless a prætor and two curule ædiles were elected out of their own body. (Sir G. C. Lewis *On the Credibility of Early Roman History*, vol. ii. 377, 396.) Part of the functions of the prætor was to administer justice between Roman citizens; in B. C. 246 another prætor, called *peregrinus*, was appointed to judge in suits between Roman citizens and foreigners; after which time the former prætor received the epithet *urbanus*. The two prætors determined their offices by lot.

So long as the Roman empire was confined to Italy, the number of prætors did not exceed two; but on the reduction of Sicily and Sardinia to the form of provinces, two more were added to govern them, and again two more were created on the subjection of Spain to the Roman yoke. Under the emperors the powers of the prætors were reduced, but the office itself existed to a late period of the empire. (Niebuhr's *Roman History*.)

Prætorian Cohorts. A body of troops among the Romans, distinguished from the rest of the army by double pay and superior privileges, first instituted by Augustus, and called by that name in imitation of the select band which attended a Roman general in battle. At their first institution the cohorts were nine in number, three being stationed at Rome, and the rest in the adjacent towns of Italy; they consisted of Italian soldiers only. Tiberius assembled them all at Rome, and placed them in a permanent camp; a measure which, while it answered the purpose of keeping the citizens in awe, proved dangerous and sometimes destructive to his successors. The emperor Severus disarmed the old guards, and established the prætorian cohorts on a new footing, increasing their number, and filling them entirely with troops draughted from the armies of the northern frontier. The command of these troops was vested in an officer called the prætorian prefect, who, as the government gradually degenerated into a military despotism, rose from the station of simple captain of the guards not only to be the head of the army, but of the provinces, and even of the law. In every department of administration he represented the person and exercised the authority of the emperor. The prætorian bands were deprived of all their privileges by Diocletian, who replaced them by other troops, and they were finally abolished by Constantine.

Prætorium (Lat.). That part of a Roman camp in which the general's tent stood, and where he took the auspices. It was raised a few feet above the level of the rest of the camp. Of the four gates of the Roman camp, that which lay next the enemy was called the *prætorian* gate.

Pragmatic Sanction, more correctly **Pragmatic Rescript.** A term of which the use seems to have originated in the Byzantine empire, signifying a public and solemn constitution or decree pronounced by a prince; distinguished from the simple rescript, which was a declaration of law in answer to a question propounded on behalf of an individual. In European history several important treaties are called by the name *Pragmatic Sanction*; among which the principal are: 1. The ordinance of Charles VII. of France in 1438, which constituted the foundation of the liberties of the Gallican church. 2. Charles VI., emperor of Germany, being without male descendants, endeavoured by an instrument termed the Pragmatic Sanction to secure the succession to his female heirs; which caused the Bavarian war of succession, 1740. 3. The law of succession to the kingdom of Naples, when ceded by Charles II. of Spain, in 1759, to his third son and his posterity.

Prairie (Fr.). A term in common use for the vast plains or savannahs of the Mississippi and Missouri. [SAVANNAHS.]

Prakrit. By this name are known certain dialects in India, which acquired greater prominence as the older Sanscrit passed gradually out of use. These dialects 'first assumed a literary position in the Sanscrit plays, where female characters both high and low are introduced as speaking Prakrit, instead of the Sanscrit employed by kings, noblemen, and priests.' From the Prakrit the modern vernaculars of India have branched off, just as the modern Romance languages have sprung immediately from the old Italian dialects, which preserved the power of growth denied to the Latin as to all other literary languages. (Max Müller, *Lect. on Language*, 2nd series, p. 38.)

Pramantha. [PROMETHEUS.]

Prangos (its Tartar name). A Persian genus of Umbelliferous herbs, one of which, the Hay plant of Thibet, was some years ago greatly lauded as a forage plant, various attempts being made to introduce it among the agricultural plants of this country, but without success. Its high reputation appears to have been undeserved, for although extremely valuable in the cold and arid regions of Thibet, where it is indigenous, and where forage of a better quality is not obtainable, it is not so much esteemed in Kashmir and other more fertile countries, where grass-pasture exists. It was first discovered by Mr. Moorcroft during his travels in Thibet, and was spoken of by him as being extensively employed as winter

fodder for sheep, goats, and frequently for neat cattle, producing fatness in a very short time, and destroying the liver-fluke, so fatal to sheep. The late Dr. Royle was of opinion that this plant was probably the kind of *Silphium* mentioned by Arrian in his account of the wars of Alexander. 'In this part of the Caucasus' (the modern Hindu Koosh) 'nothing grows except pines and silphium; but the country was populous, and fed many sheep and cattle, for the sheep are very fond of the silphium. If a sheep should perceive the silphium from a distance, it runs to it and feeds on the flower, and digs up the root and eats that also.'

Prase or **Prasem** (Gr. πράσον, *a leek*). A dark leek-green variety of Quartz, the colour of which is caused by an admixture of Hornblende. It is found at the iron mines of Breitenbrunn in Saxony, in the Harz, and in fine crystals at the Cedar Mountain in South Africa.

Praseolite (Gr. πρασον, and λίθος, stone; from its colour). An altered form of Iolite, which occurs in rounded rhombic prisms with four, six, eight, or twelve sides, having a basal cleavage and a lamellar structure, at Bräkke, near Brevig, in Norway, in quartz-veins traversing gneiss.

Prasochrome. Carbonate of lime coloured by oxide of chrome, forming a dull green incrustation on the island of Scyro, in the Grecian Archipelago.

Pratique (Fr.). A limited quarantine which the captain of a vessel is considered to have performed when he has convinced the authorities of a port that his ship is free from infectious disease.

Praxeans. An Asiatic sect of the second century; so called from their founder, Praxeas. The distinguishing characteristics of this sect were their denial of plurality of Persons in the Godhead, and their belief that it was the Father himself who suffered on the cross. The Monarchians, Sabellians, and Patripassians adopted these sentiments.

Pre-Adamites (Lat. *prior to Adam*). The legendary traditions of the East speak of nations and empires subsisting before the creation of Adam, and of a line of kings who ruled over them. The subject has been taken up, in modern times, by Isaac Lapeyrère, in his work *Præadamitæ*, 1655, wherein he endeavours to show, by deduction from Romans v. 12, &c., that Adam was the ancestor of the Jews only, the Gentiles being descended from a long anterior creation.

Pre-emption, Right of (Lat. præ, *before*, and emptio, *a purchasing*). It is sometimes directed by an Act of Parliament or other legal instrument that property for sale shall be offered in the first instance to some particular person, in which case he is said to have an option or right of pre-emption.

Pre-existence. In Philosophy, the existence of anything before another; commonly used for the existence of the human soul, in some former condition, before it became connected with its present body. It was the doctrine of the Pythagorean school, and connected with their peculiar tenet of METEMPSYCHOSIS. It was also the doctrine of Plato, who lays much stress on the rapidity of learning in early childhood, which he explains as an effort of reminiscence (ἀνάμνησις), not acquisition. Others have enlisted into the service those peculiar sensations which are sometimes raised by sights or sounds though seen or heard, as our reason would persuade us, for the first time, as if we are conscious of some prior familiarity with them. This poetical, rather than philosophical view of the subject, is beautifully illustrated in a well-known ode of Wordsworth.

Preamble (Lat. præambulare, *to go before*). The introduction or prefatory part of an Act of Parliament, explaining the reasons for its being passed. In railway bills, and other private bills of a similar nature, the preamble always contains distinct statements that it would be expedient that the objects of the bill should be effected, and that such purposes cannot be effected without the authority of parliament; and when any such bill is referred to a committee of either house, the first duty cast on its promoters is to prove the preamble, i.e. to establish the truth of these statements. After the promoters and opponents of the bill and their witnesses have been heard upon these points, the question is put to the committee 'that the preamble has been proved,' which is resolved in the affirmative or negative as the case may be, and the result of this question decides whether the bill is to proceed further or not. In Public General Acts the preamble is of little importance, and is now usually much curtailed or altogether omitted.

Prebend (Lat. præbenda). The share of the estate of a cathedral or collegiate church received by a prebendary. To all such churches there are several prebendaries attached, who reside and officiate in rotation.

Precedency (Lat. precedo, *I go first*). The relative rank of men and women in the etiquette of society; strictly it means the order in which they follow one another in a state procession, which it is part of the Office of Heralds' duty to ascertain and preserve. The following are the degrees of precedency commonly recognised in England among men: 1. The sovereign. 2. The prince of Wales. 3. The queen's consort. 4. The queen dowager. 5. The princes of the blood according to seniority. 6. The sovereign's uncles. 7. Cousins of the sovereign. 8. Husbands of princesses. 9. The archbishop of Canterbury. 10. The lord high chancellor. 11. The archbishop of York. 12. Lord high treasurer. 13. Lord president of the privy council. 14. Lord privy seal. 15. Lord high constable. 16. Earl marshal. 17. Lord high admiral. 18. Lord steward of the household. 19. Lord chamberlain of the household. (The last five, however, take precedence only of all their degree: i.e. if dukes, they precede all dukes; if marquises, all mar-

quises, &c.) 20. Dukes. 21. Marquises. 22. Dukes' eldest sons. 23. Earls. 24. Marquises' eldest sons. 25. Dukes' younger sons. 26. Viscounts. 27. Earls' eldest sons. 28. Marquises' younger sons. 29, 30, 31. The bishops of London, Durham, and Winchester. 32. Other bishops, according to priority of consecration. 33. Barons. 34. Speaker of the House of Commons. 35. Viscounts' eldest sons. 36. Earls' younger sons. 37. Barons' eldest sons. 38. Knights of the Garter. 39. Privy councillors. 40. Chancellor of the Exchequer. 41. Chancellor of the duchy of Lancaster. 42. Lord chief justice of Q.B. 43. Master of the Rolls. 44. Lord chief justice of C.P. 45. Lord chief baron of the Exchequer. 46. Lords justices of appeal, according to priority of appointment. 47. Vice-chancellors, ditto. 48. Puisne judges and barons of superior courts, and judge of Probate Court, ditto. 49. Knights bannerets made by the sovereign in person. 50. Viscounts' younger sons. 51. Barons' younger sons. 52. Baronets. 53. Bannerets not made by the sovereign in person. 54. Knights grand cross of the Bath. 55. Knights grand crosses of St. Michael and St. George. 56. Knights commanders of the Bath. 57. Knights commanders of St. Michael and St. George. 58. Knights bachelors. 59. Companions of the Bath. 60. Companions of St. Michael and St. George. 61. Eldest sons of the younger sons of peers. 62. Baronets' eldest sons. 63. Knights of the Garter's eldest sons. 64. Bannerets' eldest sons. 65. Knights of the Bath's eldest sons. 66. Knights' eldest sons. 67. Baronets' younger sons. 68. Esquires of the king's body. 69. Gentlemen of the privy chamber. 70. Esquires of the knights of the Bath. 71. Esquires by creation. 72. Esquires by office or commission. 73. Younger sons of knights of the Garter. 74. Younger sons of bannerets. 75. Younger sons of knights of the Bath. 76. Younger sons of knights bachelors. 77. Gentlemen entitled to bear arms. 78. Clergymen not dignitaries. 79. Barristers at law. 80. Officers in the army and navy not esquires by commission. 81. Citizens, burgesses, &c.

Precedents. In Law, precedents are decided cases, followed as authorities in courts of justice. Precedents, strictly speaking, are binding on tribunals only when they are in the shape of actual judicial decisions of the point in question. What English lawyers term an extrajudicial opinion—i.e. the opinion of a judge pronounced where it was not called for to decide the issue—can have authority only from the character of the individual judge, and not as a precedent. When the principles of equity were as yet unsettled, it was held by many that precedents were inapplicable in that branch of law; as its very name seemed to imply that each case should be governed by the judge's opinion of its individual merits. But Lord Keeper Bridgman, among others, seriously refuted this supposition; and precedents have long been of as much authority in courts of equity as in those of common law. A form of an instrument or a pleading, from which others corresponding in circumstances may be copied, is also termed a *precedent*.

Precentor (Lat. præcentor). The leader of a choir. In most cathedrals of old foundation in England the precentor ranked next to the dean. In the more modern foundations the precentor is usually a minor canon.

Preceptories. In the Middle Ages, a kind of benefices so called as being held by the more eminent Knights Templars, whom the grand master created and styled *Præceptores Templi*. Of these preceptories, sixteen are recorded as belonging to the Templars in England (*Mon. Ang.*); but it is thought by some writers that these places were merely cells, subordinate to their head-quarters, the Temple in London. [COMMANDERY.]

Precession of the Equinoxes. A term used in Astronomy to denote a small annual variation in the position of the line in which the planes of the ecliptic and equator intersect each other, in consequence of which the sun returns to the same equinoctial point before completing his apparent revolution with respect to the fixed stars.

The longitude of a star is counted on the ecliptic eastward from the first point of Aries, or the vernal equinox. If the line of the equinoxes, therefore, maintained always the same position with respect to the celestial sphere, the longitude of the stars would be invariable. But on comparing the actual state of the heavens with the observations recorded by ancient astronomers, it is found that the longitudes of all the stars have considerably increased, and all to the same degree; so that the celestial sphere appears to turn round the axis of the ecliptic with a slow motion from west to east, or in the same direction as the sun in his annual revolution. The phenomena, however, will be in all respects the same, if, instead of supposing the whole firmament to advance in the order of the signs, we suppose the axis of the earth's equator to have a slow motion about the axis of the ecliptic in the opposite direction. This will give to the line of intersection of the two planes (which is the line of the equinoxes) a retrograde motion from east to west, in consequence of which the sun, whose motion is from west to east, arrives at the equinoctial points sooner than if they remained at rest; and therefore the equinoxes, and the seasons which depend on them, come round before the sun has completed an entire circuit of the sphere. On this account the motion has been called the *precession of the equinoxes*.

Although the existence of the precessional motion of the equinoctial points was known at an early period in the history of astronomy, the imperfection of instruments prior to the sixteenth century did not permit of observations being made with sufficient accuracy to determine its precise rate, which must therefore be deduced from comparisons of the longitude of the same star calculated from modern

observations; but, on account of the extreme slowness of the motion, the determination must still be liable to some uncertainty, unless a considerable interval of time has elapsed between the epochs of observation. According to Bradley's observations the longitude of the star *Spica Virginis*, at the beginning of the year 1760, was 200·4944°. At the beginning of 1802 Maskelyne found the longitude of the same star to be 201·0781°. The difference is 0·5837° in forty-two years, which gives 50·03″ in a year. The comparison of a great number of observations on different stars gives 50·1″ for the annual precession. According to this estimate, the equinoctial points retrograde on the ecliptic at the rate of one degree in 71·6 years, and therefore will require a period of about 25,800 years to make a complete revolution. The constant of precession for the year 1868 is 50·2565″.

The physical cause of the precession of the equinoxes is the combined action of the sun and moon on the mass of matter accumulated about the earth's equator, and forming the excess of the terrestrial spheroid above its inscribed sphere. The matter of this spheroidal shell, in reference to the effect of the solar attraction on it, may be regarded as forming a ring about the earth in the plane of the equator. Now the solar force, acting on the part of the ring which is above the ecliptic, may at every point be resolved into two parts, one parallel to the plane of the equator, and the other perpendicular to it; and the resultant of all the latter forces must be a force tending to impress on the ring a motion round the intersection of its plane with the ecliptic. The same thing holds true of the other half of the ring which is under the ecliptic. If the earth, therefore, had no motion of rotation, the plane of the equator would turn round the line of its intersection with the ecliptic until it coincided with the latter plane. But while the equator has this tendency to revolve about an axis in its plane, it has also a rotatory motion about an axis perpendicular to its plane; it will, therefore, according to a well-known theorem in mechanics, revolve not on either of these axes, but on one which divides the angle between them, so that the sine of its angular distance from each axis is in the inverse ratio of the angular velocity round that axis. [ROTATION.]

The motion now described may be assimilated to that of a top put into rapid motion, with its axis inclined to the horizon. In this position the axis of the top slowly revolves about the vertical drawn from the point on which it rests, describing the surface of a cone; and any section of the top perpendicular to the axis, if produced to meet the horizon, will at every instant intersect that plane in a new line; and the line of intersection will revolve with a motion corresponding to that of the axis in the direction opposite to that of the rotation.

The attraction of the moon on the spheroidal shell produces a similar effect to that of the sun, and in a still greater degree, in the ratio of about 5 to 2. It is easy to see that the effect of both those bodies in displacing the equator of the terrestrial spheroid must vary with their position in reference to it; for if they moved in the plane of the equator, there would evidently be no displacement, and their power to produce it is greatest when the earth is in such a position that the inclination of the equator to the ecliptic, or to the plane of the lunar orbit, is a maximum. This inequality of action gives rise to another highly important astronomical phenomenon; namely, an apparent vibratory motion of the equator, which Bradley (who first discovered its cause and period) significantly denominated the *nutation of the earth's axis*. [NUTATION.]

In consequence of the precession of the equinoxes the sun's place among the zodiacal constellations, at any given season of the year, is now greatly different from what it was in remote ages. Some time before the age of Hipparchus the first points of Aries and Libra corresponded to the vernal and autumnal equinoxes, and those of Cancer and Capricorn to the summer and winter solstices. These points have now receded 30° from the constellations to which they then corresponded. The vernal equinox now happens when the sun is in Pisces, the summer solstice when he is in Gemini, the autumnal equinox when he is in Virgo, and the winter solstice when he is in Sagittarius. Astronomers, however, still employ the term *the first point of Aries* to denote the position of the vernal equinox. On this account the *signs of the zodiac*, or ecliptic, which are fixed in respect of the equinoctial points, must be carefully distinguished from the *constellations*, which are movable with respect to those points. (Airy's *Mathematical Tracts*; *Encyc. Brit.* art. 'Precession;' Woodhouse's *Physical Astronomy*; La Place, *Mécanique Céleste*; Poisson, 'Sur le Mouvement de la Terre autour de son Centre de Gravité,' in the *Mém. de l'Acad. des Sciences de Paris*, tom. vii. 1829.)

Precious Garnet. [GARNET; PYROPE.]

Precious Metals, The. For reasons given in the article MONEY, all civilised nations have accepted gold and silver, or both, as media of exchange, or a common measure of values.

Cost of the Precious Metals.—When any country is itself a producer of these commodities, the charge at which they are procured, and their consequent value, depends as in other articles on the cost of their production; and if they are produced by mining, the land in which they are mined will pay a rent, in just the same way as a copper, lead, or coal mine pays a rent, if they should be found in such abundance as to be procured at less cost than that at which they can be imported (the produce not being sufficient for the wants of the community). A large portion of the silver brought into the market of this country is of home produce, being found in lead, and easily refined by a simple but ingenious method known as *Pattison's process*. The amount of gold, however, found in the British Isles is quite

unimportant by the side of that which is imported.

If, however, the precious metals are imported, the cost at which they are procured is measured by the cost of the commodities with which they are exchanged. They may cost much or little to the producer; but this will make no difference to the purchaser in foreign countries, the sole gauge by which he will measure their value being found in the charge at which he is to procure goods to exchange against them. Hence, if the gold and silver in the world were suddenly increased at little cost to its possessors, or if it were to accumulate without decay or loss, prices would inevitably be affected by a general rise, or, in other words, the price of gold and silver as measured by other commodities would fall. The former of these phenomena took place in the middle of the sixteenth century, though much more slowly than is commonly supposed; the latter would occur in this country, if it were not the case that gold and silver are as rapidly exported as they are imported, the course of trade in the precious metals using this country only as a reservoir from which supplies are derived to other parts of the world. It is plain, also, as gold and silver are imported into non-producing countries in exchange for commodities, that those countries which supply articles of the highest value at the least cost of production, and are nearest to the mines, will get the precious metals at the cheapest rate, i.e. prices would naturally be highest in such countries; if they are not, it is because the same cause which gives a greater purchasing power over gold and silver—the efficiency, namely, of labour—enables the possessor of money to purchase commodities at lower rates, and of course to procure, as he does the metals themselves, all other imports at cheaper rates.

Distribution of the Precious Metals.—Mr. Ricardo has said, 'that gold and silver having been chosen for the genera' medium of circulation, they are by the competition of commerce, distributed in such proportions among the different countries of the world, as to accommodate themselves to the natural traffic which would take place if no such metals existed and the trade between countries were purely a trade of barter.' This position, which is perfectly sound, shows, in the first place, how ill judged are all attempts to control or direct the import and export of the precious metals, and how, in order that they should be distributed at all, it was inevitable that the precautions taken in past times should be defeated; in the next, that, as far as trade is concerned, no country ever takes more or less of the precious metals than is necessary for the wants of its commerce, and for its reserve against contingencies; and, next, that when the course of trade with any country necessitates a large and continuous exportation of the precious metals, the absorption is not for purposes of currency, but for the arts, for personal display, or for hoarding. The machinery by which this distribution takes place is by the course of trade, and especially by the fluctuations of the foreign exchanges.

Sources of the Precious Metals.—No register of the imports of the precious metals was taken at the custom-house before November, 1857, i.e. subsequent to the time in which the Californian and Australian discoveries were made. Between 1858 and 1863, the two most important sources of gold bullion and specie have been Australia and the United States, the large exports from the latter country being relative not only to the mines, but consequent upon the state of the exchange during the war, and the forced paper circulation. *The quantity supplied from the mines is steadily decreasing.* After the supply from the New World, the largest contributions are from Russia. On the other hand, the supplies of foreign silver come chiefly from Mexico and France, from the former in the shape of bullion, from the latter in coin, the process by which gold has been substituted for silver currency in France not having been yet completed. Again, the largest amount of gold bullion and specie passes to France, of silver bullion and specie to Egypt, for China and India, coin being absorbed in China, bullion in India, this exportation of specie to the latter locality having been enormously increased of late years by the necessity of purchasing the inferior Indian cottons in large quantities at greatly enhanced rates. There cannot be a doubt that this vast importation of silver into India will, concurrently with a sounder system of banking and finance, produce great effects upon prices in that country, and tend ultimately to produce great social changes.

Subjoined are tables of the imports (1) of gold, (2) of silver, for the six years 1858–63; (3) the exports of gold, (4) of silver, for the same period.

1. Gold imports.		2. Silver imports.	
	£		£
1858	22,793,126	1858	6,700,064
1859	22,297,698	1859	14,772,458
1860	12,584,684	1860	10,393,512
1861	12,163,937	1861	6,583,108
1862	19,903,704	1862	11,752,772
1863	19,142,665	1863	10,888,129

3. Gold exports.		4. Silver exports.	
	£		£
1858	12,567,040	1858	7,061,836
1859	18,081,139	1859	17,607,664
1860	15,641,578	1860	9,893,190
1861	11,238,372	1861	9,573,276
1862	16,011,963	1862	13,314,228
1863	15,303,279	1863	11,240,761

Precious Opal. A name for those varieties of Opal which exhibit a rich play of prismatic colours. It is found in irregular nests and veins, disseminated in trachyte, at Czerwenitza in Hungary, in Mexico, Ceylon, Iceland, &c.

Precipitate (Lat. præcipitatus, part. of præcipito, *I cast headlong*). A result of chemical decomposition, in which a substance is thrown

down in a solid, and generally in a finely divided state, from a liquid. The term *red precipitate* has been especially applied to the red oxide of mercury.

Precognition. In Scotch Law, the preliminary examination of witnesses respecting the commission of a criminal act, in order to ascertain whether there is ground for a trial, and to serve as directions to the prosecutor.

Predaceans (Lat. præda, *booty*). The English name used by Kirby as synonymous with the *Carnassiers* of Cuvier. [FERINES.]

Predazzite. A variety of Bitter Spar mixed with Brucite, which forms mountain masses at Predazzo in the Southern Tyrol. It has a granular structure, and is white with a vitreous lustre on the planes of cleavage.

Predestination (Lat. prædestinatio, the corresponding Greek term used by St. Paul being προορισμός). The belief that God has from all eternity decreed whatever comes to pass. In a theological sense, it is thus defined in the seventeenth Article of the English church: 'Predestination to life is the everlasting purpose of God, whereby, before the foundations of the world were laid, He hath constantly decreed by His counsel, secret to us, to deliver from curse and damnation those whom He hath chosen in Christ out of mankind, and to bring them by Christ to everlasting salvation.' The Lambeth Articles, agreed to in 1595 by a portion of the clergy, assert that 'God from eternity hath predestinated certain men unto life, certain He hath reprobated.' Theological writers have generally forborne to use the word *predestination* with respect to the rejected: 'Nefas est dicere Deum aliquid nisi bonum prædestinare.' (August. *De Dono Perseverantiæ.*) [ELECTION; CALVINISM.]

Predetermination. In Scholastic Philosophy, that concurrence of God which determines men in the performance of their actions, good or evil; called physical predetermination, or premotion.

Predial (Lat. prædium, *a farm*). Of or belonging to a farm. Thus we often read of *predial* slaves and slavery, in opposition to *domestic*.

Predicable (Lat. prædicabilis, *that may be said* of anything). In Logic, a term which can be affirmatively predicated of several others. The notions expressed by such terms are said to be formed by the faculty termed *abstraction*, after the particular circumstances characterising each individual have been withdrawn from it. The predicables are commonly said to be five: GENUS, SPECIES, DIFFERENCE, PROPERTY, and ACCIDENT (which is either separable or inseparable). [LOGIC.]

Predicaments. In Logic, certain general heads, or, in logical phraseology, *summa genera*, under one or other of which every term may be arranged. Aristotle enumerated ten predicaments; others, by subdividing some of these, have increased their number. Those of Aristotle are: substance, quantity, quality, relation, place, time, situation, possession, action, suffering. [ATTRIBUTE; CATEGORY; LOGIC.]

Predicate. In Logic, is, of the two terms of a proposition, that which is affirmed or denied of the other. [TERM; PROPOSITION; LOGIC.]

Predication. [LOGIC.]

Predisposing Cause. In Medicine, any circumstance which renders the body susceptible of disease.

Preface (Lat. præfatio, from præ, and fari, *to speak*). The observations prefixed to a work or treatise, intended to inform the reader of its plan and peculiarities.

Prefect. An important political functionary in modern France. Under the old régime, the officers who were sent round to the provinces to superintend the details of administration on behalf of the king were at first styled *maîtres des requêtes*. These were made permanent local officers in the reign of Henry II., and afterwards attained many additional powers, with the title of intendants. These were abolished at the Revolution, when various attempts were made to establish elective local governments. By a law of the year 1800 prefects were first appointed for the departments, with powers similar in many respects to those of the old intendants, with a council of the prefecture, and a general council of the department; which, however, fell into disuse. With slight variations, the prefects retain the same jurisdiction. They are, in some respects, analogous to our sheriffs; but with far greater powers. They possess not the nominal only, but the actual direction of the police establishment, within their respective departments, together with extensive powers of municipal regulation: the arrondissements or districts into which the departments are subdivided are under sous-préfets appointed by them. Their power, however, is controlled by that of the council of the prefecture, which acts in some measure as a court of appeal from the prefect, taking cognisance of various cases within the sphere of his administrative interference, if legal disputes arise upon it.

Prehnite. A hydrous silicate of alumina, of a greenish colour, originally discovered at the Cape of Good Hope, by Colonel Prehn. It is found in Cornwall, in Scotland, in the trap rocks of Edinburgh; and in the Isles of Mull and Skye. In Ireland it occurs in the granite of the Mourne Mountains.

Prelacy. [EPISCOPACY.]

Prelate (Lat. prælatus, *preferred*). A term commonly applied to bishops, archbishops, and patriarchs, in Christian churches. Anciently, mitred abbots seem also to have been called prelates.

Prelude (Lat. præludo, *I play before*). In Music, the preface or introduction to a movement, usually in the same key as the movement which it precedes; being, in fact, a preparation to the ear for what is to follow.

Premier (Fr.). The name generally given to the prime minister of England.

Premisses (Lat. præmissa). In Logic, the first two propositions of a syllogism. [SYLLOGISM.]

Premium (Lat. præmium, *profit*). In Finance, that market value of shares and stocks, in which the price paid for the ownership of the securities created exceeds the sum originally paid for them. When the market price and the sum paid are exactly equal, the stock is said to be at *par*; when the market value is less, the stock is at a *discount*. In the system under which loans were negotiated during the latter half of the eighteenth, and the beginning of the nineteenth centuries, the advantage gained by those who took the risk of subscribing the loan which was to be distributed subsequently among the general public, was called the *premium*, and the fact that in effect this premium or excess over the market price of public securities was always paid in the negotiation of any fresh loan, was quoted in order to show the inherent absurdity of the sinking fund of Dr. Price, by which loans were created for the purpose of liquidating debt by the agency of a compound interest. [FUND, SINKING.]

Premonstratensians (Fr. Prémontrés). A religious order of regular canons instituted in 1120 by St. Norbert (whence they are also called Norbertines), at Premonstratum, in Picardy, which is said to have derived its name from being *pointed out* by the Virgin. The canons of this order followed the rule of St. Austin, and were sometimes called White Canons, from the colour of their habits. They were brought into England about 1140, where they are said to have established thirty-five houses.

Prensiculantia (Lat. prenso, prehenso, freq. of prehendo, *I seize*). A name applied by Illiger to an order of Mammalia, corresponding with the *Glires* of Linnæus and the *Rodentia* of Cuvier, and indicative of the prehensile faculty with which the fore paw is endowed in most of the species of this order.

Preparation (Lat. præparatio). In Music, the previous adjustment of two notes by whose introduction a note which is to become a discord is heard in the preceding harmony. [MUSIC.]

Prepense (Lat. præ, and pendo, *I weigh*). In Law, an epithet, applied to MALICE, usually rendered in English by *aforethought*.

Preponderance (Lat. præpondero, *I outweigh*). In Artillery, the excess of weight of the portion of a gun in rear of the trunnions over the part in front. [GUN.]

Preposition (Lat. præpositio, from præpono, *I place before*). In Grammar, that part of speech which denotes the relations between objects; as *in*, *to*, *upon*. [GRAMMAR.]

Prerogative (Lat. prærogativa, applied in ancient Rome to that tribe, or century, which had the privilege of giving its votes—rogare suffragia—first at the comitia). A word in English Law, signifying the special rights of the sovereign, both as chief of the kingdom in point of honour, and as supreme magistrate intrusted with the execution of the laws. Prerogatives are said to be of two kinds, *direct* and *incidental*: the first, such as belong to the sovereign essentially by virtue of his high political character; such as the inviolability of his person, the appointment to offices and places of trust, the command of the army, the power of making war and peace, the supremacy of the national church, his legislative authority, &c.; and the latter, such exceptions as are made in his favour from the ordinary rules of law in private matters. Such are, with respect to debts, the power to levy first execution before other creditors, and of levying by the prerogative writ of extent; the power of taking goods and chattels in succession, which no other corporation can do; exemption from all customs, general and special, as to descent of lands, in a case where any such custom would have the effect of preventing lands held jure coronæ from passing to the successor; the abstract dominion of all lands and hereditaments by the fiction of universal occupancy; the right to derelict lands by the sudden retiring of the sea; the dominion of seas, navigable rivers, &c.

Prerogative Court. The court in which wills were formerly proved and administrations taken of the effects of intestates when the deceased had property in two or more dioceses of the same province, in which case the jurisdiction belonged to the archbishop of the province, by his prerogative. The jurisdiction in all such cases now belongs to her majesty's Court of Probate.

Presbyopia (Gr. πρέσβυς, *old*, and ὤψ, *the eye*). An imperfection of vision commonly attendant upon the more advanced periods of life, in which near objects are seen less distinctly than those at a distance. It is usually caused by a change in the consistence of the crystalline lens, effected as age advances; changes also by flattening of either the lens or the cornea may produce this state of vision. The change in consistence by induration of the lens interferes with the action of those muscles which compress it in health in order to adapt it to varying distances. Convex glasses must be used to remedy the defect. It often happens that one eye is more affected than the other, and in this case glasses of different foci should be used.

Presbyters (Gr. πρεσβύτερος, *elder*). An order of ministers in the Christian church, frequently mentioned in the New Testament as having the spiritual care of distinct congregations, and exercising a general superintendence over the concerns of the church. [EPISCOPACY; PRESBYTERY.]

Presbyterians. The name given to that body of Christians who have embraced the Presbyterian form of government. [PRESBYTERY.]

Presbytery (Gr. πρεσβυτέριον, *a council or assembly of elders*). That form of ecclesiastical polity according to which there is no gradation of order in the church, but which vests church government in a society of clerical and lay presbyters, or, in common phraseology, ministers and lay elders, all possessed officially of equal rank and power. The presbyterians

maintain that the words *presbyter* (πρεσβύτερος) and *bishop* (ἐπίσκοπος) are synonymous and interchangeable terms; that we nowhere read in the New Testament of bishops and presbyters, or of pastors of different rank, in the same church; and that deacons are laymen, whose sole duty it is to take charge of the poor.

The first presbyterian church, in modern times, was founded in Geneva by John Calvin, about 1541; and the system was thence introduced into Scotland, with some modifications, by John Knox, about 1560, but was not legally established there till 1592. For about a century from this date there was a continual struggle in Scotland between presbytery and episcopacy for superiority. The latter (which was patronised by the court) predominated in 1606; but was superseded by the former (to which the great body of the people were attached) in 1638. Presbytery kept its ground from this period till the revolution in 1660, when episcopacy again obtained the ascendency, which it maintained till 1688; soon after which it was abolished, and the national church of Scotland declared presbyterian--a form which it has since retained. The most numerous bodies of dissenters from the Scottish established church, such as the Associate and Relief Synods, are also Presbyterians; their cause of secession being that the church had relaxed the strictness of presbyterian principles.

Presbytery has never flourished much in England. An attempt was made to render the established church presbyterian in the reign of Charles I.; and this object was signally promoted by the famous Assembly of Divines at Westminster. In 1649, presbytery was sanctioned by the English parliament, but it was never generally adopted, or regularly organised except in London and in Lancashire. (Murray's *Life of Samuel Rutherford*, Edin. 1828, ch. viii.) Upwards of 2,000 presbyterian clergy were ejected from their cures in England, in consequence of the Act of Uniformity, in 1662. There are still many congregations (about 150) in England, particularly in the northern counties, called presbyterian. In Ireland, chiefly in the province of Ulster, there are about 500 presbyterian congregations. There are upwards of 100 such congregations in our North American possessions; and presbytery has also been introduced to a greater or less extent in the other British colonies.

In the United States of America presbytery embraces 5,660 congregations, with 4,785 ministers. (*Ency. Brit.* 8th edit. vol. xxi. p. 422.) The same system, though somewhat modified from that which obtains in Scotland, is established in Holland. (Steven's *Brief View of the Dutch Eccles. Establishment*, ed. 1839.) It still exists, though to a very limited extent, in Geneva; it prevails also less or more in several of the other Swiss cantons.

The constitution of the church of Scotland is as follows: The kirk session is the lowest court, and is composed of the parochial minister and of lay elders, the number of whom varies in different parishes, but is generally about twelve. The minister is moderator ex officio. This kirk session exercises the religious discipline of the parish; but an appeal may be made from its decisions to the presbytery, the court next in dignity. The presbytery, from which there is a power of appeal to the synod, is composed of the ministers of a number of contiguous parishes (varying in number in different cases), with a lay elder from each. A moderator, who must be a clergyman, is chosen every half-year. A presbytery generally meets once a month, but it must meet at least twice a year; and it may hold pro re natâ meetings. This court takes young men on trial as candidates for license; ordains presentees to vacant livings; has the power of sitting in judgment on the conduct of any of its members, and can depose them; and has the general superintendence of religion and education within its bounds. The synod, which meets twice yearly, is formed of the members, both lay and clerical, of two or more presbyteries. At every meeting a moderator is chosen, who must be a clergyman. The general assembly is the highest ecclesiastical court, its decisions being supreme. It meets annually in the month of May, and sits for ten successive days. Unlike the inferior courts, it consists of representatives chosen by the various presbyteries, royal burghs, and universities of Scotland. The number of representatives from presbyteries depends on the number of members of which each is composed. No presbytery sends less than two ministers and one lay elder; and none more than six ministers and three elders. The total number of members of the general assembly is 363, of whom about 200 are ministers. The assembly chooses a new moderator yearly, who, in recent times, is always a clergyman. The assembly is honoured with the presence of a representative of the sovereign, under the title of lord high commissioner; but this high functionary takes no part in the proceedings of the court, except in opening and closing or dissolving its sittings, and has no voice in its deliberations. The assembly before its close appoints a commission, which is equivalent to a committee of the whole house, being composed of all the members of assembly, and one minister additional, named by the moderator. The commission meets quarterly; but may hold pro re natâ meetings.

The income of the clergy, which may average about 250*l.* yearly, including manse and glebe, is regulated by the state; and they are nominated to livings by patronage. They have no liturgy, no altar, and with few exceptions no instrumental music. The Scottish presbyterians do not kneel, but stand in time of prayer; and in singing the praises of God they sit. The sacrament of the Lord's Supper is not administered in private houses to any person under any circumstances whatever. (*The Directory for the Public Worship of God, by the Westminster Assembly of Divines.*) Pluralities have been prohibited; and the

residence of clergymen within their respective parishes has always been imperative. Their creed is rigid Calvinism, and may be found embodied in the *Westminster Confession of Faith* and the *Larger* and *Shorter Catechisms*. But though the faith of the Scottish Presbyterians, whether churchmen or dissenters, is Calvinistic, not a few of the Presbyterians in other countries have adopted an Arminian, and not unfrequently a Unitarian creed. (Adams' *Religious World Displayed*, ii. 289–305; Lord King's *Inquiry into the Constitution of the Primitive Church*; Forbes' *Presbyterian Letters*.)

PRESBYTERY. In Architecture, the space between the altar and the easternmost stalls of the choir, answering to the *solea* of the ancient basilicas.

Prescription. A title acquired by use and time to incorporeal hereditaments, such as a right of way or of common, and the like. All prescription is either personal, as when it is in a man and his ancestors, or it is in right of a particular estate; which last being in a man, and those whose estate he hath, is called prescription in a *que* estate. It presupposes a lost grant, and can therefore give a title to those things only which can pass by grant. After uninterrupted enjoyment for forty, and in many cases for thirty or twenty years, a primâ facie title arises by prescription to the thing enjoyed; and unless such enjoyment have continued under some consent or agreement, the title becomes in sixty years absolute and indefeasible. The time of prescription in most of the ordinary instances to which it applies is now regulated by 2 & 3 Wm. IV. c. 71.

Presentation (Lat. præsento, *I present* or *show*). In Ecclesiastical Law, the act of offering a person to the bishop to be instituted to a vacant benefice.

Presentation, Feast of. In Ecclesiastical usage, a feast otherwise called the Purification of the Blessed Virgin. [PURIFICATION.]

Presentment. In Law, presentment is properly the notice taken by a grand jury of any offence from their own knowledge or observation without any bill of indictment laid before them at the suit of the crown, as the presentment of a nuisance or the like. The term is commonly used to include also inquisitions of office, and indictments by a grand jury. It is also used to express the formal notice taken in copyhold courts of the deaths of tenants, surrenders and admittances taken out of court, and other similar circumstances. Bills of exchange and promissory notes are said to be *presented* for acceptance or payment.

Preservation of Meat. Before giving an account of the different processes at present employed for the preservation of meat, it will be advisable to consider briefly the principles which determine the putrefaction of flesh under the decomposing influences of air, moisture, and warmth.

Muscular tissue, of which flesh is composed, consists mainly of the animal albuminous principle known to chemists as FIBRIN in a coagulated or semi-solid condition, permeated in all directions by a fluid composed partly of blood and partly of substances secreted from it. This fluid, which constitutes nearly three quarters, by weight, of all fresh meat, is composed of albumen in the soluble condition, the soluble salts of the blood, the crystallisable animal principles kreatine and kreatinine, lactic and butyric acids, the phosphates of potash, magnesia, and lime, and a small quantity of common salt —the whole being dissolved in a *watery fluid*. The albuminous principles fibrin and albumen are remarkable for the readiness with which they undergo decomposition, and break up into simpler substances, when under the influence of air, moisture, and warmth. The fluid constituents of flesh are, consequently, precisely in the most favourable condition for undergoing prompt decomposition, when submitted to the action of the atmosphere at a temperature even slightly elevated above freezing.

The process of putrefaction has been examined with great care and minuteness by several eminent chemists, but a detailed description of their researches would take up too much space; it will be sufficient for our purpose to know that albumen is a highly complex body, containing carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorus, soda, and potash, and that when partly decomposed itself, it has the peculiar property, in common with its congeners fibrin and casein, of acting as a ferment, and inducing decomposition in the other animal substances with which it comes into contact. Decomposition being once fully set up, the solid and liquid portions of the flesh become gradually converted into gases containing fetid ammoniacal, sulphuretted, and phosphoretted compounds. These gases continue to be emitted until the whole of the meat is decomposed, nothing being left behind but the mineral constituents of the flesh and of its fluids.

Thus we see that four causes are concerned in the putrefaction of animal matter: air (or rather the oxygen which it contains), moisture, warmth, and decomposing albumen. Now, as no putrefaction can take place without a supply of oxygen, the whole of the processes at present in use are dependent on the more or less perfect protection of the meat from the action of the air. Thus, whether meat is preserved by being frozen, dried, salted, enclosed in air-tight cases, or covered with various substances, such as oil, varnish, or gutta percha, we may practically consider that their efficacy depends on one and the same cause—the exclusion of the air from contact with the meat.

Meat-preserving processes may be arbitrarily divided into the following classes:—

1. The application of cold.
2. Drying.
3. Salting.
4. Immersion in certain fluids.
5. Inclosure in air-tight vessels in vacuo or inert gases.

1. *The Application of Cold.*—The simplest of all preservative methods is that adopted in North

America, Russia, and other cold countries in the winter time, when frozen meat, fish, and vegetables form staple articles of consumption. During the coldest parts of the year, the markets of Montreal, Archangel, and St. Petersburg are filled with these frozen commodities, which when gradually thawed by being exposed to a gentle heat are found to possess all the qualities of fresh provisions, although they are generally many weeks old. The same means has been adopted for sending fish and other provisions to this country from distant parts, and the writer has tasted game shot in the prairies of Western America and sent to London packed in ice, whose only fault consisted in its being rather too fresh. The same method has also been employed to insure the successful exportation of salmon and trout ova to Australia [PISCICULTURE]; and the use of ice as a preservative of meat, or at any rate as retarding its putrefaction, is constantly resorted to during hot weather in this country. In the case of frozen provisions, the air being, of course, excluded from them by the ice in which, so to speak, they are immersed, no putrefactive action can take place. When a diminished temperature only is employed, the decomposition is simply retarded, but not altogether prevented.

2. *Drying*.—The next simplest process is that of drying the meat thoroughly, either by natural or artificial means. In all hot countries, more especially in South America, the natives are in the habit of cutting their meat into thin strips, and exposing these to the sun until they are thoroughly hard and dry. The American Indians pound their meat in rude mortars until it forms a paste, which is mixed with fat. This paste is afterwards made into bricks, dried and sold to the hunters under the name of *pemmican*. From its mode of preparation, pemmican contains a large amount of nutritive matter in a comparatively digestible state, and is sufficiently palatable to those who have nothing else to eat. Pemmican is prepared in large quantities at Gosport for the use of the navy. The beef, trimmed and deprived of fat as much as possible, is cut in thin slices, which are placed in hot plates until they become perfectly dry. They are then reduced to a coarse fibrous powder, and mixed with a certain amount of fat. To some kinds sugar and currants are added. It makes excellent broth, containing a large amount of nutritive matter, and is preferred by many sailors to canistered preserved meat. South American beef, or charqui (*chair cuite*, Fr.), is made by cutting the meat into slices, salting, and drying by artificial heat. Large quantities were sent to this country in 1863–4, and sold retail at 4*d*. per pound; but owing to many samples being half-tainted when they arrived here, the retail buyers became disgusted, and the sale has greatly diminished. The salting, of course, deprived it of a large portion of its nutritive principles, and the drying rendered it so hard as to be cooked and digested with great difficulty. All drying processes depend for their value on the coagulation and consequent hardening of the albumen contained in the meat, by which it becomes impervious to the action of the air. The same object is gained by the process of *smoking*, or exposing the meat, first partially salted, to the fumes of burning wood or peat. Peat or wood smoke contains a certain quantity of KREASOTE, a bitter principle which coagulates the albumen on the outer parts of the meat. Meat and fish may be preserved a short time by simple smoking; but the so-called smoked beef, ham, and fish, is in reality salt beef, ham, and fish smoked on the outside to obviate the necessity of packing it in salt.

3. *Salting*.—We come now to the various salting processes, the first of which is the ordinary method of salting beef and pork. The following is the process adopted, with slight modifications, for the beef and pork used by the navy. Twenty-four hours after the animals are slaughtered, the beef is cut up into 8lb. pieces, the pork into pieces of half that weight; they are then rubbed with salt, and placed in tanks filled with dry salt, where they remain from eight to twenty days, according to circumstances, after which they are stored in casks of dry salt. This prolonged application of salt has the effect of dissolving out nearly the whole of the nutritious juices of the meat, ultimately leaving little behind but hardened fibrin.

Several means have been tried to obviate this destruction of the valuable matter contained in the meat; the latest of these being that devised by Professor Morgan of Dublin. It is, we believe, a modification of a method originally invented by M. Gannal. The animal is killed in the usual way by a blow in the head, care being taken not to rupture any of the large bloodvessels. The chest is then cut open, and the heart laid bare by an incision in the pericardium. The right and left ventricles are next opened, and the blood allowed to run out by laying the animal on its side. A pipe furnished with a stopcock and coupling at the outer end is now introduced into the aorta through the left ventricle, a piece of stout cord being passed round the pipe and the aorta to hold them together. The coupling is then connected with eighteen or twenty feet of Indian rubber piping, which communicates with a tank or trough containing the salting liquor elevated to the height of the length of the Indian rubber tubes. The tap being turned, the salting liquor at once enters the aorta, and running through the whole of the animal's vascular system flows out at the right ventricle. This salting liquor is ordinary brine in which a small quantity of saltpetre has been dissolved, and may be used several times, its use being to clear out the vessels and prepare them for the second salting liquor, which is composed of one gallon of brine, half a pound of saltpetre, two pounds of sugar, half an ounce of monophosphoric acid, and a small quantity of spice to every hundredweight of meat.

The saltpetre (nitrate of potash) and phosphoric acid are added to supply the potash salts and phosphates which are washed out by the liquor. The connection with the aorta being made as before, the right ventricle is this time tied up securely, and the tap being turned on, the liquor in a very few minutes percolates through every vessel in the body, even those contained in the skin, hoofs, and horns. In the course of a few days the animal is skinned and cut up into the usual 8 lb. pieces, which are either casked with salt or dried in a hot-air chamber.

Professor Morgan has established several factories in different parts of South America for the preparation of beef by this method. The Admiralty also have had his plan under trial for several months, and the officers who have tested it report favourably upon it.

Other preservative agents, such as the acetates of soda and ammonia, the chloride of aluminum, and several others, have at various times been experimented on; but common salt with a certain admixture of saltpetre and sugar appears to form the best material for salting.

Solution of salt appears to act in preserving meat by filling up its pores with a liquor that will not absorb oxygen, but of all processes it is the most pernicious and unphilosophical. As we have before remarked, the largest amount of nutritive matter resides in the fluids contained in the flesh. To say nothing of the albumen, these fluids are charged with salts of potash and lime, and several phosphates, all of which are absolutely necessary for the formation of blood, muscle, and bone, in the living being. The two animal principles, kreatine and kreatinine, are also found in the liquid permeating muscular fibre, and are considered by several chemists to be analogous in their action on the human subject to theine, so that beef *tea* is not such a misnomer as one might suppose. By the process of salting, all these important substances are gradually washed out into the brine, and in course of time nothing remains but hardened fibrin, which, by itself, can afford little nourishment to the human body. From this it will be readily seen that the use of salt meat in any form is unwholesome unless care be taken to supply some of the constituents that remain in the brine and water in which it has been soaked. By Professor Morgan's method a large amount of valuable nutritive material must be lost in the process of washing out the capillaries and other smaller vessels; and when the meat is cut up and casked, the objections made to ordinary salt meat still hold good, although in a more limited degree. Various plans have been devised from time to time to recover the nutritious matters dissolved in brine, but hitherto without success. The process of removing the salt by dialysis appears to offer the best hope of effecting this object.

4. *Immersion in Fluids.*—This class of preservatives may be soon dismissed. Treacle, strong syrup, glycerine, weak vinegar, solution of sulphurous acid, and several other liquids, have all been tried; but from one cause or other they all seem to have failed practically. Sardines, pilchards, and other small fish are preserved in oil in enormous quantities with the greatest success; but from the expensive character of the material, the principle, though sound, is inapplicable to provisions in large pieces. It need hardly be stated that alcohol, benzol, turpentine, solution of arsenic, corrosive sublimate, &c., although perfectly applicable in the case of anatomical preparations, are utterly useless for substances intended for food.

5. *Preservation in Vacuo and Inert Gases.*—These methods are intended for the preservation of meat in its unsalted state. It is hardly possible to over-estimate the importance of a perfect process for preserving meat in a fresh condition. The history of fresh preserved meat is closely connected with Arctic discovery. The exertions made by navigators to discover the North-West passage first created a demand for this form of food, it being found that the evils arising from living exclusively on salted provisions were fearfully aggravated by the rigours of a cold climate. The Admiralty were therefore incessant in their efforts to induce manufacturers to devise some process for doing away with salt meat; and towards the beginning of the present century numerous experiments were made by various persons, with, however, but little success. As soon as the modification of Appert's process by Donkin, Hall, and Gamble was made practically perfect, it was at once tested by the Admiralty, who sent out large quantities of the preserved fresh meats to the Arctic regions by ships starting on voyages of discovery. The provisions were reported on favourably by the officers in charge of the expeditions; and, their value in cold climates being once known, their use was soon extended to the East and to the West Indies and other tropical regions. For ship use, they were found invaluable, and at the present time hardly a vessel leaves this country without a supply of fresh preserved provisions. In India they are extensively used as luxuries in the towns, and as necessities in the remote districts where fresh meat of any kind is scarce and bad.

The first successful attempt made to preserve meat fresh was by M. Appert, a French gentleman, who in 1810 received a prize of 12,000 francs offered by the Board of Arts and Manufactures in Paris. In the following year, M. Durant, a colleague of M. Appert, took out a patent for the process in this country. The patent was subsequently declared to be invalid, the Society of Arts and Manufactures of London having previously presented a premium to a Mr. Luddington for a method of preserving fruit without sugar, the principle of which was said to be the same as that adopted by Appert. The patent was nevertheless purchased by Messrs. Donkin, Hall, and Gamble for 1,000*l*. They at once effected a great

improvement by abolishing the use of glass vessels, and substituting tin canisters in their stead. Although the use of air-tight vessels was an essential part of Appert's process, it seems to depend for its value more upon the cooking, or rather over-cooking, of the meat, by which the albumen was rendered insoluble, than upon the perfect exclusion of oxygen, that gas having been found in appreciable quantities in tins containing meat in a perfectly sound condition.

Appert's process consisted in partly cooking the meat, placing it in a glass vessel in a bath of chloride of calcium, heating it to about 240° for a length of time depending on the size of the piece of meat, and then hermetically sealing the lid. After this, it was again heated for a shorter or longer time, and the process was considered finished.

Donkin and Gamble's process, which is now adopted in all parts of the world, is as follows, The meat, which has been previously parboiled, is placed in tin cylinders containing a rich soup or gravy; the lids, which are pierced with a small hole, being soldered down air-tight. They are then immersed in a bath of brine or chloride of calcium, and heated to boiling-point, until the meat contained in them is supposed to be completely cooked. While the steam produced by the boiling soup is issuing from the orifice in the cover, the jet of vapour is suddenly checked by the application of a wet rag, a drop of molten solder being dexterously applied to the hole at the same moment, and so the case is hermetically sealed. The sealed tins are once more, in order to insure the perfect coagulation of the albumen, submitted to the hot bath, for a time proportionate to their size and the nature of their contents. On cooling, the ends of the canisters, which are purposely made of thin tin-plate, become slightly convex from the outward pressure of the atmosphere. They are afterwards exposed to a temperature of 100° Fahr. in a hot-air chamber for several weeks, at the end of which time they are examined. If any of the ends are found to have flattened or bulged outwards, either the case has not been soldered air-tight, or the contents have putrefied and liberated the gases, causing the ends to become convex from inward pressure.

The process has been greatly improved by Messrs. McCall and Co. of Houndsditch, who introduce into the tins a small quantity of sulphite of soda to effect the absorption of any traces of free oxygen which under the most favourable circumstances may lurk in the cases. This salt, which both in the solid and liquid state has a great affinity for oxygen, is used in the proportion of twelve grains to every pound of meat. The sulphite of soda is at first contained in a small air-tight tin capsule, which is soldered to the interior of the lid of the case, the salt being retained in its place by a plug of soft solder which melts at 218° Fahr., i.e. 6° above boiling-point. The meat being prepared as in Donkin and Gamble's process, it is placed in the tin, the lid being soldered down and heated in the salt bath until steam issues at the hole in the lid. A drop of solder is applied as before, and the steam inside the air-tight case becoming superheated, the soft solder on the capsule melts and releases the sulphate of soda. The effect of this improvement is to lessen the necessity for prolonged steaming and over-cooking, which is one of the great objections to the ordinary method of meat preservation. In the case of soups, the salt is generally mixed with them before they are enclosed in the canisters.

An improvement upon all these processes has lately been patented by Messrs. Jones and Trevethick, of Botolph Lane. It is conducted in the following manner:—

The raw meat, without any further preparation, is wrapped up in a clean piece of cloth and placed in a tin, the lid of which is soldered down. From the top of the case projects a small tube, which is placed in communication with an air pump, a very ingenious contrivance being adopted to prevent the cases collapsing from the outer pressure of the air. This is accomplished simply by placing them in water in an air-tight vessel. When all the air is exhausted, pure nitrogen gas, which is absolutely without action on animal matter, is let into the case. This has the effect of diluting almost infinitely any traces of oxygen that may remain in the meat or tin. The nitrogen is in its turn exhausted, and a minute portion of sulphurous acid gas is allowed to enter the cylinder, having the effect of perfectly absorbing any remaining traces of oxygen. Another charge of nitrogen is then admitted, and the case is finally soldered, the nitrogen, by filling the case, of course preventing any collapse from atmospheric pressure.

The great merit of this process consists in the fact that the meat is preserved in its natural and uncooked state. At the jury dinner which took place at the International Exhibition of 1862, mutton, beef, and poultry, many months old, were produced, which, for anything that could be guessed from their perfect freshness of flesh and flavour, might have been killed the day previously. When the cases were opened, the poultry and game had the appearance of having been but an hour from the poulterer's; and although the butcher's meat appeared on close inspection to be slightly redder than usual, nothing could be detected, either by touch, taste, or smell, that would preclude an ordinary observer from declaring it to be perfectly fresh. This method is one of the most valuable yet invented, and if it can be practically worked will be of inestimable benefit to all classes of the community.

Patents have also been taken out for preserving meat by enclosing it in air-tight cases along with vessels containing sulphide of calcium and other salts capable of absorbing the oxygen from the air in the case; but none of these have been yet applied to actual practice.

The principle of preserving meat by perfectly excluding the air is also applied largely

in the case of sausages and potted meats. Various experiments have been tried, and numberless patents have been taken out, for methods of covering provisions with various varnishes, gutta percha, Indian rubber, wax, paraffin, plaster of Paris, &c. &c.; but as none of them are practicable, it would be useless to describe them.

President (Lat. præsideo, *I sit foremost*). A title applied to many officers in various capacities, but generally denoting a pre-eminency, either temporary or fixed, among a number of persons assembled for a definite purpose. Thus the superior of a board or council, &c. is generally entitled president, as is anyone who is called to preside over an occasional meeting, or to fill the chair at a club, dinner, &c.; although the old English title of chairman is frequently used on such occasions.

The supreme executive officer of the United States of America is styled *president*. The qualifications required of a person raised to this dignity are, to be a natural-born citizen of the age of thirty-five years, and to have resided fourteen years within the states. The election is by electoral colleges in every state. These colleges contain, in each state, a number of electors equal to all the senators and representatives of that state in congress; but their appointment varies in different states, and at different times; sometimes it is made by their respective legislatures, sometimes by general election throughout the state, sometimes part of the electors are chosen by district and part by general election. The colleges in each state vote by ballot for a president (and at the same time for a vice-president); and the votes of all the electors, taken in this manner, are counted by the president of the senate: if in this numeration any person is found to have an absolute majority of votes, he is duly elected; if not, the election is made by the house of representatives between the three persons having the highest number; in which case the votes are taken by states, and a majority of all the states is necessary to constitute a choice. On two occasions, of which the last was in 1824, no candidate having had a majority of the whole number of voters, the house of representatives has proceeded to make the election; and, on the last of these occasions, a majority of states chose a candidate (Adams) who had a smaller number of electoral votes than one of his opponents (Jackson). On one occasion, in 1800, the states balloted thirty-six times before any candidate could obtain an absolute majority. Should the president die during his term of office, he is succeeded by the vice-president. In this manner the present president, Andrew Johnson, succeeded to the office on the assassination of Abraham Lincoln.

In his legislative capacity, the president has the power of approving bills sent to him after passing both houses of congress, or of returning them to the house in which they have originated with his objections annexed. In the latter case, the bill must be reconsidered by that house; and if, on reconsideration, it obtain a majority of two-thirds in both houses, it passes into a law. In his executive capacity, he is commander-in-chief of the army and navy of the Union, and of the state militias when called into the service of the Union; he has the power of reprieving and pardoning except in cases of impeachment; he has power to make treaties, with the consent of the senate (by a majority of two-thirds); he nominates ambassadors, consuls, judges of the supreme court, and all other officers of the United States whose appointments are not vested elsewhere by the constitution.

The supreme magistrate of the French Republic, 1848, was also styled *president*, elected for four years by universal suffrage.

President, Lord, of the Council. The fourth great officer of state in England; appointed by letters patent under the great seal, durante bene placito.

Press (Fr. presse). The machine (whether worked by hand or by steam) by which books, &c. are printed. Very little improvement in the construction of this instrument took place from the first introduction of the art of printing into Europe till the late Earl Stanhope introduced his press. The old press was made of wood, with an iron screw that had a bar fitted in it; to the lower end of this screw was attached, horizontally, a flat piece of wood, called the *platen*, which, being brought down by means of the screw, pressed the paper upon the face of the types; and thus the impression was obtained. This press has, however, entirely given place to presses made of iron. Lord Stanhope's press is constructed of iron, with a screw; but the bar is fixed to an upright spindle to which a lever is attached connected with a second lever fixed to the top of the screw by a connecting bar. These two levers are placed at different angles to each other; and when the platen is brought down to the face of the types, and power is wanted, the two levers take such a position with each other as to act with the greatest advantage, and thus an almost incredible accession of power is gained, which enables the pressman to print larger sheets of paper in a superior manner, and with greater ease to himself. This press maintains its superiority in some respects over all others.

The great improvement thus effected in the printing press excited other ingenious men to exert their abilities in attempts at further improvements; among whom was a Mr. George Clymer, an American, who brought forward an iron press, called the Columbian, in which he discarded the screw, and obtained his power entirely by levers. This press has great power, and consequently great capacity, but for the common run of printing it does not work so easily as the Stanhope. These two are looked upon as the best presses.

There are many other presses which are great improvements upon the old construction, and which are held in estimation by printers, but the limits of this work will not admit of the details of their respective merits.

The *book press*, in the warehouse department, used for pressing books previous to their delivery, is the common screw press, with a perpendicular screw, and screwed down by means of an iron bar; it is also used for pressing paper, when wetted, previous to being printed on, for the purpose of making it in better condition for the process; and also in cylindrical or machine printing, to cause it to lie flat, as it is apt otherwise to wrinkle, particularly when in large sheets, in being carried round the cylinders. In large establishments Brahmah's hydraulic press is generally used for these purposes, as being much more powerful, and also more expeditious, not only in its use, but also in its effect.

PRESS. A machine for the purpose of compressing or squeezing bodies. Any of the mechanical powers may be used for this purpose. When constructed on a large scale, the hydrostatic pressure of water is the power generally employed. [HYDROSTATICS.]

PRESS. A term metaphorically applied either to the whole literature of a country, or to that part of it which is more immediately connected with newspapers or other periodical publications.

Press Proof. In Printing, a good impression of a sheet by which it is read over carefully before being printed off.

Pressirosters (Lat. pressus, *flattened*; rostrum, *a beak*). A tribe of wading birds, including those which have a flattened or compressed beak.

Pressure (Lat. pressura). Dr. Young defines pressure to be 'a force counteracted by another force, so that no motion is produced.' (*Lectures on Nat. Phil.*) Thus, when a heavy body is supported on a table, or the ground, the force of terrestrial gravity, which, if the support were removed, would cause the body to descend towards the centre of the earth, being destroyed at every instant by the resistance of the support, produces a pressure. A pressure and a moving force differ from one another only in this respect, that the infinitely small velocities which the pressure tends to produce are incessantly destroyed by the resistance of the obstacle; whereas those that are actually produced at every instant by the moving forces are accumulated in the moving body, and produce a finite velocity after a finite time. The pressures of two different bodies are, therefore, to each other as the masses multiplied by the infinitely small velocities which they tend to produce in the same instant of time, and which they would produce if the bodies were free to move.

Pressure, Centre of. [HYDROSTATICS.]

Presswork. In Printing, the operation of taking impressions from types, &c. by means of the press; distinct from *composing*, which is arranging the types to prepare them for press. By *fine presswork* is meant work printed with the best paper and ink, and with the utmost care at a hand press.

Presto (Ital.). In Music. [TIME.]

Presumption of Law. The assuming the truth of a certain state of facts by the ordinary custom of the law. It is either *juris et de jure*, which is a presumption which no evidence to the contrary can be admitted to traverse, as the presumption of incapacity in a minor with guardians to act without their consent; or it is *juris* only, which may be traversed by evidence, as where the property of goods is presumed to be in the possessor until the contrary is shown.

Presumptive Heir. [HEIR.]

Pretender. The name by which the Chevalier Charles Stuart and his father are usually known, from their having pretended a right to the British crown, from which they had been excluded.

Prevarication (Lat. prævaricatio, *a going in a crooked direction*). In Roman criminal law, several special kinds of fraud have been so entitled; in particular, that of an agent or advocate, who by collusion with the opposite party damages his employer. The popular English sense of the word is altogether different.

Preventer. On Shipboard, a term applied to any rope, chain, bolt, &c., which is placed either temporarily or permanently as a deputy or duplicate for another similar instrument. Its object is to relieve the other rope, &c., or to take its place in the event of carrying away.

Prevention (Lat. prævenio, *I come before*). In Civil Law, prevention takes place where one of two parties equally authorised to commence legal proceedings does so, and thereby forestalls the other.

Preventive Service. [COAST GUARD.]

Previous Question, The. In English parliamentary usage (whence it has been borrowed in the practice of other legislative bodies) the *previous question* is termed by Mr. May (*Parliamentary Practice*) 'an ingenious mode of avoiding a vote on any question which is proposed.' When a question is about to be put by the Speaker (in the House of Commons—the usage of its committees is different), a member may interpose by moving that the same question 'be *now* put,' and if this be negatived, then the main question cannot be put at that time. [PARLIAMENT.]

Prévôtales, Cours (Fr. *courts of prévôts* or *provosts*). Certain tribunals of summary jurisdiction, which existed in France before the Revolution, and were for a short time reestablished in 1815.

Priam. In Mythology. [PARIS.]

Priapus (Gr.). In Mythology, a son of Dionysus (Bacchus) and Aphroditê (Venus); but there are several accounts of his parentage. He was looked on as the cause of fertility to fruits and flocks. From the worship specially paid to him at Lampsacus, he is often spoken of as Hellespontiacus. (Hor. *Sat.* i. 8; Ov. *Fast.* i. 415.) [LINGA; MYSTERIES; PHALLUS; YONI.]

Price (Ger. preis, Fr. prix, from Lat. pretium). In Political Economy, the estimate

in money of the value of any article in demand. It has been distinguished as twofold: the natural price, i. e. the ratio which the money value of commodities has to the cost of production; and the market price, i. e. the rate at which, consequent on supply and demand, a commodity is exchanged for money, at any particular time. The market price continually oscillates about the natural price; it is occasionally below it, and under certain circumstances may far exceed it. The two will coincide only when the demand rises and falls exactly with the supply, a state of prices which cannot, of course, ever be permanently secured. Furthermore, price is to be distinguished from value. Value is either relative to the cost of production, or to the demand which is made for the commodity, but values exchange exactly against values. In price, however, two elements have to be considered: not only the value of the article sold, but the cost of producing the general measure, money, has to be taken into account. Hence there may be a rise or fall in prices, consequent not upon the cost of production or the demand of purchasers, but upon the relative value of the precious metals. Thus the value of wheat in relation to the value of wool or any other commodity will remain the same; for if a quarter of wheat costs as much to produce as forty pounds of wool do, the value of the measure and the weight will be identical. There cannot, therefore, be a general rise in values. But prices have risen and fallen according to the dearness or cheapness of the precious metals. For instance, a quarter of wheat was worth, say, 6*s.* 8*d.* five hundred years ago, and is worth 50*s.* now, i. e. there is a rise in price amounting to seven and a half times, partly consequent upon the diminution of the weight of silver in the same denomination of currency, partly because silver is procured at a cheaper rate, i. e. at less labour, at present than at that time.

The history of the great change of prices which took place in the sixteenth century, has not yet been written. It was due partly to a radical change in the currency, partly to the distribution of the precious metals over the Old World consequent upon their discovery in the New. Had these metals been produced and distributed according to the general process by which mines are worked at present, though there can be no doubt that a rise in prices must have eventually taken place owing to the comparative ease with which silver was found, yet the facts would have been different, both in character and degree. After the occupation of Peru by the Spaniards, the mines whence the largest quantity of the new silver was procured were worked by the compulsory labour of the natives; and the silver having been procured at little cost to those who reaped the fruit of this labour, was exchanged cheaply against imported commodities. If, however, the mines had been worked by voluntary labour, the addition would have been more gradual, and the cost of production being fully equal to that of any other commodity, the effects would have shown themselves more slowly. It is, we believe, due to the fact that the discoveries of gold and silver in California, Australia, and New Zealand have been turned to account by the labour of voluntary colonists, that, prodigious as has been the amount added to the stock of bullion possessed by the civilised world, the rise in prices which is suspected to have ensued from this addition is still a matter of doubt, and if decided affirmatively may be even then assigned to other and co-ordinate causes.

The price of a commodity is not based upon its rarity, or on its utility, but on the demand for it, i. e. on the difficulty of satisfying the desire of possessing it. Some of the metals which have been recently discovered are of excessive rarity, being disseminated in the ore from which they are taken in very minute quantities, as for instance by two or three grains to the ton. But, except to those who are curious, they have no value, and no price, and will have none unless some use in the arts, which shall create a demand commensurate with the cost of producing them, should hereafter arise, and thus create a need of them. This was the case with the metal platinum. When it was first discovered, it was exhibited in the form of dust, or of a very slightly coherent powder. As in the existing state of chemical science, it was wholly infusible, it could not be made to possess the ordinary qualities of the useful metals, malleability and ductility. When, however, Dr. Wollaston discovered a means of welding it, and its remarkable properties in this shape became known, it became an article of great commercial value, having been employed to form stills for the concentration of sulphuric acid, a commodity in its concentrated form of such mercantile importance, that its consumption is said to be the measure of the economical progress of a nation. Again, the utility of some objects is of immediate and permanent significance. Human life can be continued but for a few minutes in the absence of air, or when its supply is scanty, or when its quality is depraved. But air, since there is no difficulty in procuring it, has no value and no price. In deep mines, or in diving bells, it has a price, because labour is necessary to supply it; in other words, because it is difficult of attainment.

In consequence of the fact, that difficulty of production, and demand, concur in elevating the price of commodities, certain general rules may be laid down which may be said to denote the laws which govern the rise and fall in the price of commodities, the value of money being supposed to remain unchanged.

1. In commodities of urgent demand, but of such a quantity as cannot be susceptible of immediate increase, the price of a deficient supply will rise far above the ordinary rate, the aggregate quantity available for consumption selling for a far larger sum than the ordinary amount could be sold for. This is the case, for instance, with the amount of food in a city which is closely

besieged, and in that possessed by a nation which imports no supplies from abroad, whenever a dearth or famine arises. In this country, during the existence of the corn laws, the nation put itself voluntarily into a state of siege, and suffered the evils of famine when it had all the means of plenty. At the present time, as trade in corn is free, communication rapid, and the harvest goes on over the world all the year round, the contingency of a dearth in the necessaries of life, as far as bread is concerned, is as remote as the risk of a general deficiency of harvests over the whole world could be.

2. In commodities the demand for which is constant, but the supply is absolutely fixed, the price of the commodity will rise with the demand, and will stop only with the contingency of the rate of profit or satisfaction not being realised on the purchase. This is the case with land available for building or cultivation. There is no known limit which can be put to the rent or purchase (the two terms differing only as annual and permanent possession) of land which is demanded for buildings in advantageous sites for commerce, as long as a rate of profit may be procured on the land thus rented or purchased. A rise in the rent, or in the value of the fee simple of land, is derived wholly from increased production; and the productiveness of the soil, whether in trade or agriculture, is as yet, and long will be, an indeterminate quantity, for in all likelihood the rate of production from the soil of this country, even in the existing state of agricultural science, is only half what it might be were it possible to apply larger capital to the soil by the liberation of land from some of the real burdens which affect it, the hindrances, namely, to its distribution.

3. In commodities the demand for which is steady, and the supply capable of extension at increased cost to the producer, the price will rise steadily according to the demand and the increased cost. Thus clothing can be manufactured from several materials. A deficiency in the supply of one of these will be met by an increased rise of another. Thus, were cotton the only material available for clothing, the deficiency of the American market would have raised the price of clothing at a rate analogous but not equal to a rise in the price of food consequent upon a general scarcity. It would not be an equal rise in price, for a greater economy may be maintained in the use of clothes than in that of food. The full rise was, however, met to some extent by the use of other raw materials, as wool, silk, flax, alpaca, and the like. So it has constantly been found that a deficiency in the supply of a great convenience of life from one source is met by the discovery of the same or a similar utility in some new quarter. The hindrances put on the use of cane sugar during the great French war, led to the cultivation of beet for the supply of this commodity. A similar cause suggested the discovery of certain sources of saltpetre. A deficiency in the supply of hemp has led to the extensive use of jute. Deficiencies in the raw material of paper have led to the use, as yet partial, of other tissues than cotton and flax. It has been stated, though on somewhat doubtful authority, that the blockade of the Southern ports of the American Union during the late civil war has been the means by which economical discoveries of great importance have been made in some of the states which composed the extinct Southern confederacy.

4. In commodities which can be produced in indefinite quantities at no increased cost, or at only such an increase as is due to the demand for labour, the price, even if demand increases greatly, will be affected only to a slight extent. Thus iron and coal can as yet, it appears, be supplied from this country in indefinite quantities, the amount produced being determined solely by demand. In this case, if labour be abundant and the competition for land from which these articles can be obtained is not so great as to create a general rise in rents for mining localities, prices will remain stationary. Even when a rise in rents is effected, and labour is comparatively dear, improvements in the process of production may serve to neutralise the consequences which might otherwise have fallen on consumers. Thus the consumption of coal and iron for the home and foreign trade has increased to an enormous extent during the last two years, but without a corresponding rise in price. Here, again, the theory which concludes that a great fall has of late years taken place in the price of the precious metals, or, in other words, that a general rise in prices has occurred, may be refuted, if it be shown, first, that these metals have been produced at equal cost to the miner, or, which is far more important, have been procured at equal cost by the exporter of them.

5. In commodities whose use is wholly voluntary, a great deficiency of supply may occur without any great increase of price. Thus the price of wine in countries where the use of this stimulant is confined to a small section of the community, and only the better growths are consumed, may not rise very markedly even when the vintage has failed to a very great extent. Spanish white wines, we are told, have risen largely in price during the last two or three years. This, however, is not due to deficiency of crops, but to a very great increase in the demand, consequent on a greater inclination and a wider power of purchase among the community. In short, where the article is one of voluntary use, a slight increase in price, or even a threatened increase of price, may stop demand, and arrest the enhancement of the market value.

Price of Money. This expression is exceedingly ambiguous. It means occasionally the rate at which the precious metals are procured in exchange for other commodities. In this sense the laws which govern the price of gold and silver are in no way different from

those which regulate the cost of other commodities. It is by means of these laws that the precious metals are distributed over the world, the demand, namely, for their use in commerce and the arts, and the power of exchange which the possessor of every object in demand holds in the several markets of the world. It may also, and often does mean, the ease or difficulty with which capital may be lent or borrowed; in other words, the fulness with which credit is given or taken, and from this point of view it is influenced by the state of the foreign exchanges, i.e. by the need which there may be of exporting money or increased quantities of goods at lower prices in order to equalise transactions, and by the rate of discount in the advances made by bankers and bill brokers. The origin of this use of the phrase, *the price of money*, to express what is in effect the price of credit, is to be found in the universal, and indeed necessary practice of estimating all values by money prices. The money is a mere instrument, often being but the basis of a series of transactions representing in their aggregate amount much more than the gold and silver in which they are estimated. For the phenomena which characterise these facts, see DISCOUNT and EXCHANGE.

Price at the Mint, or Mint Price.—The value of gold at the Mint is 3*l.* 17*s.* 10½*d.* the ounce, British standard, and any person may bring gold of standard value to the Mint in quantities of not less than 10,000*l.* in value, and receive in exchange, after the time necessarily spent in manufacturing the same into currency, the same amount, weight for weight, in gold coins, the rate of coinage being 1,869 sovereigns to 40 lbs. troy weight of gold, the gold being $\frac{11}{12}$ fine. The expression, therefore, *Mint price of gold*, only denotes the value of the currency contained in the troy ounce.

The general theory of prices, and the largest information as to prices of commodities, and the causes which have induced, during the history of the last sixty or seventy years, fluctuations in prices, are to be found in the work of the late Mr. Tooke, continued by Mr. Newmarch. Of all the questions discussed in these volumes, those of the prices of corn and the price of mercantile accommodation are the most important. Much, indeed, of the reasoning on both these heads has been controversial. Dissertations on the causes which induce fluctuations in the price of food have, it is true, been rendered comparatively unimportant by the changes which have happily occurred in consequence of the reform of the tariff and the repeal of the corn laws; but the question whether the price of money, in the technical sense of the rate of discount, has not been made liable to excessive fluctuation, is still an open one. On one point all persons are agreed, that there is nothing which is more desirable for producer, dealer, and consumer, than a generally uniform price, and that anything which reduces the oscillations of the market price to the lowest possible amount in relation to the natural price, is of the highest importance and benefit.

Prices of Foreign Produce. The price of an article procured from a foreign country depends not upon the cost at which it is produced, but on the cost at which it is procured. For instance, the cost of a cask of Spanish wine is determined not by the price of labour, the rate of profit, and the rent of land in Spain, but by the elements which make up the cost of the commodity or commodities against which the wine is exchanged in the country to which it is exported. Were all transactions between countries carried on in money, the rule would still hold good, though to a less extent; for money is produced and imported just as any other commodity is, by exchange for other commodities, and the specie may be procured by one country at cheaper rates than it can be by others. In case, however, that both countries produced gold and silver, and produced them at the same cost, the price of a commodity like that of wine would be equal in the two countries, with the addition in the case of the importing country of the cost of carriage. Such a combination of circumstances can, however, occur but rarely, if indeed it be not wholly hypothetical. Hence it may happen, that, value for value, a commodity can be procured at cheaper rates in an importing country, than it is in the country which produces it, and if the cost of carriage were omitted, continually would be. Hence, also, the price of the precious metals may be lower in countries which do not produce them, than in countries which do.

Prick Post. In Architecture, a post in wooden buildings framed intermediately between two principal ones. The term is generally used to express the intermediate post between two guide ones that are driven into the ground in the case of a wooden fencing.

Pricking Up. In Architecture, the first coating of lime and hair in work of three coats upon lath. It is executed in London with coarse stuff made with road drift or Thames sand; and the surface is scratched over with the trowel to enable the succeeding coats to obtain a better hold of the pricking-up coat.

Prickles. In Botany, the hard, sharp-pointed conical processes found on the epidermis of plants.

Prickly Ash. The name of the *Xanthoxylon fraxineum.*

Prickly Pear. One of the names of the *Opuntia* or Indian Fig.

Priest (A.-Sax. preost; Gr. πρεσβύτερος, *elder*). In Christian churches, a minister who presides over the spiritual affairs of a congregation. The word is by many regarded as representing the Greek *ἱερεύς*, who, like the Jewish priest, had both a sacrificial and mediatorial character; and this idea is embodied in the Catholic or sacerdotal theory of the Christian priesthood.

Primæ Viæ (Lat. *the first ways*). In

Medicine, a term employed to designate the stomach and bowels.

Primage. A certain allowance paid by the shipper or consigner of goods to the master and sailors of a vessel for loading the same. It varies in different places according to their respective customs.

Primary or **Primitive.** In Geology, rocks underlying the ordinary and recognisable fossiliferous rocks of a district have in the early days of geology been called by these names. The names assume that such rocks were formed before those which contain fossils; an assumption not at all safe, since many rocks distinctly igneous and plutonic are comparatively modern. There is no proof whatever that we have any of the primary or primitive rocks of the earth brought to the surface for our examination. Some are certainly very ancient, but they may have been modified from formations yet more ancient. The terms *hypogene*, *crystalline*, and *metamorphic* express simple facts of observation, and are far more convenient.

Primary Assemblies. A name applied to those assemblies in which all the citizens have a right to be present and to speak, as distinguished from representative parliaments. Primary assemblies are of necessity practicable only in small states, such as ancient Athens, and seem to require the existence of a dependent class shut out from all political privileges, and perhaps deprived even of personal liberty. On the other hand, they supply to the members a higher political education than that which is available for the generality of citizens in large states governed by representative parliaments. (Freeman's *History of Federal Government*, vol. i. ch. ii.)

Primary Colours. The principal colours into which a ray of white solar light may be decomposed or separated. Newton supposed them to be seven: red, orange, yellow, green, blue, indigo, and violet. Mayer considered some of these to be secondary colours, and that there are only three primary colours in the solar spectrum; namely, red, yellow, and blue, certain proportions of which constitute white light and all the other colours. (*Opera inedita*, 1775.) Dr. Young assumes red, green, and violet as the fundamental colours. (*Lectures on Nat. Phil.* p. 439.)

It is now known that every portion of the spectrum is a primary or pure colour, and cannot be resolved by further refraction; consequently it is erroneous to assume that some of the prismatic colours are produced by the superposition of others, as green by blue and yellow, orange by red and yellow, &c. [Chromatics; Light.]

Primate (Lat. primas, primatis). A prelate of superior dignity and authority. In England, the archbishop of York is entitled Primate of England; the archbishop of Canterbury, Primate of all England.

Primates (Lat.). The name given by Linnæus to the first order of animals in his *Systema Naturæ*, which associated man with the monkeys and bats, and corresponded to the Bimana, Quadrumana, and Cheiroptera of Cuvier.

Prime (Lat. primus, *first*). In Arithmetic, two numbers are said to be *prime* to each other, or one number is said to be prime to the other, when the two have no common measure except unity. A *prime number*, frequently termed *a prime*, is one which is not exactly divisible by any other number except itself and unity. In the theory of numbers, *complex primes* are also considered. [Integer.]

We are not yet in possession of any general method for finding primes, although there are many ways of detecting whether an assigned number is or is not prime. [Fermat's and Wilson's Theorems.] Vega's *Tables* give all primes less than 400,000.

For properties of prime numbers, see Fermat's edition of *Diophantus*; Euler's *Algebra*, and *Analysis Infinitorum*; Legendre, *Essai sur la Théorie des Nombres*; Barlow's *Elementary Investigations, &c.*; and especially the *Disquisitiones Arithmeticæ* of Gauss, of which there is a French translation by Delisle. Much useful information on the subject will also be found in Prof. J. S. Smith's Report on the Theory of Numbers in the *Proc. of Brit. Assoc.* for 1859–65.

Prime and Ultimate Ratios. A method of calculation invented by Newton, and employed in the *Principia*, being an extension and simplification of the ancient method of exhaustions. It may be thus explained: Let there be two variable quantities constantly approaching each other in value, so that their ratio or quotient continually approaches to unity, and at last differs from unity by less than any assignable quantity; the *ultimate ratio* of these two quantities is said to be a ratio of equality. In general, when different variable quantities respectively and simultaneously approach other quantities considered as invariable, so that the differences between the variable and invariable quantities become at the same time less than any assignable quantity, the ultimate ratios of the variables are the ratios of the invariable quantities or *limits*, to which they continually and simultaneously approach. They are called *prime ratios* or *ultimate ratios*, according as the ratios of the variables are considered as receding from, or approaching to, the ratios of the limits. (*Principia*, book i.)

Prime Vertical. In Astronomy, the vertical circle of the sphere which intersects the meridian at right angles, and passes through the east and west points of the horizon. In dialling, prime vertical dials are those which are projected on the plane of the prime vertical, or a plane parallel to it.

Primer. This word, signifying originally a religious work employed in the Roman Catholic service, is now generally used to denote the first book for children.

Primer. In Artillery, a small supplementary tube, used with the forty-pounder and

seven-inch screw breech-loading guns. It is placed in the horizontal part of the vent before the vent-piece is placed in the gun, its object being to communicate the flame from the ordinary tube to the cartridge.

Primer Seisin (Nor. Fr.). An ancient branch of the royal prerogative in England, by which it had possession for a year of the lands and tenements of which a tenant in capite died seised, if the heir was of full age; or, if not, until he was of age. [TENURE.]

Primine (Lat. primus, *first*). In Botany, the outermost sac or covering of an ovule; either composed of cellular tissue only, or traversed by numerous veins or bundles of tubes.

Priming (Lat. primus). In Architecture, the first coat of painting.

PRIMING. When the steam leaves a boiler, it carries over with it a certain quantity of water in little globules given off by the bubbles that come to the surface, and there burst. This quantity is sometimes very great when a large passage is opened, on account of the ebullition which frequently causes the water to pass over in the state of a substance resembling soap curds. The water so thrown off is technically said to *prime*. This is a great source of annoyance and loss of power.

Priming and Lagging. The alternate acceleration and retardation of the times of high water, caused by the combined action of the sun and moon. [LAGGING.]

Primipilus (Lat.). In Roman History, the name of the centurion of the first cohort of a legion, who had charge of the eagle. (Smith, *Dictionary of Greek and Roman Antiquities*, art. 'Exercitus;' *Mém. de l'Acad. des Inscr.* vol. xxxii.)

Primitiae (Lat.). The first fruits of any production of the earth, which were uniformly consecrated to the Deity by all the nations of antiquity. [FIRST FRUITS.]

Primitive (Lat. primitivus, *first of its kind*). In Geology. [PRIMARY.]

PRIMITIVE. In Grammar, a word neither derived from any other language, nor compounded from any other words of the same.

Primitive Colours. In Painting, these colours are red, yellow, and blue, from the mixtures of which other colours may be obtained—the secondary, and the tertiary; and by the addition of white or black, every variety of tint may be acquired.

Primitive, Complete. [DIFFERENTIAL EQUATIONS.]

Primitive Methodists. [RANTERS.]

Primitive Roots. In Algebra, an imaginary n^{th} root of unity is said to be *primitive* when it is not at the same time a root of unity of a lower order than the n^{th}. If $p_1, p_2 \ldots p_r$ denote the prime factors of n, then there are $n(1-\frac{1}{p_1})(1-\frac{1}{p_2})\ldots(1-\frac{1}{p_r})$ primitive n^{th} roots of unity. The successive powers $a, a^2, a^3, \ldots a^{n-1}$ of any one of these primitive roots constitute the complete series of n^{th} roots of 1. The successive powers of a non-primitive root, on the other hand, only yield a certain number of the complete set of roots. [ROOTS OF UNITY.]

In the theory of numbers, the roots of a binomial congruence $x^n \equiv 1$ (mod. p), where p is a prime number, which are not at the same time roots of any other congruence of the same form, and of lower degree, are also called *primitive roots appertaining to the exponent n*. Their number is the same as before, and equal to the number of primes less than n. As before, too, the characteristic property of the primitive roots of a congruence is that the residues of the successive powers of any one of them constitute the complete set of roots, primitive and non-primitive, of that congruence. Thus the congruence $x^4 \equiv 1$ (mod. 5) has the primitive roots 2 and 3, and the non-primitive roots 1 and 4. In fact, the successive powers of 2 are 2, 4, 8, 16, whose residues for the modulus 5 are respectively 2, 4, 3, 1. On the other hand, the powers of 4, viz. 4, 16, 64, 256, have the residues 4, 1, 4, 1, which do not exhaust the whole set of roots.

The above roots 2 and 3 are also called the primitive roots of 5, and generally the primitive roots of the congruence $x^{p-1} \equiv 1$ (mod. p) are called the *primitive roots of the prime number p*. The following determination of the primitive roots of 7 will further illustrate the general method; for further details, treatises on the theory of numbers must be consulted. From the series of numbers 1, 2, 3, 4, 5, 6, reject 1, 2, 4, which are quadratic residues; the numbers 3, 5, and 6 remain, of which 6, as being the residue of a cube, must be also rejected, when 3 and 5 will alone remain as primitive roots of 7. Desmarest, in his *Théorie des Nombres*, Paris 1852, has given a table containing the primitive roots of all primes less than 10,000.

Primogeniture. The right of the eldest son, and those who derive through the eldest son, to succeed to the property of the ancestor. Among ancient nations, the Jews alone appear, as far as is known, to have recognised this usage among their institutions. For some notice of the policy of the system of primogeniture, see SUCCESSION, LAW OF.

Primordial Utricle. In Vegetable Physiology, the first layer of protoplasm thrown down over the interior of a vegetable cell.

Primrose (from pryme rolles, its name in old books and MSS. &c. 'It is called Pryme Rolles of pryme tyme, because it beareth the first flowre in pryme time.' Chaucer writes it *primirole*). This common little plant affords an extraordinary example of blundering. Primirole is an abbreviation of Fr. primeverole, Ital. primaverola, dim. of prima vera, from fior di prima vera, the first spring flower. Primirole, as an outlandish unintelligible word, was soon familiarised into prime rolles, and thus into primrose. The rightful claimant of the name, strange to say, is the daisy. (Prior, *Names of British Plants.*) The common Primrose is the *Primula vulgaris* of botanists.

Primulaceæ (Primula, one of the genera). A natural order of herbaceous perigynous Exogens of the Cortusal alliance, inhabiting the northern and colder parts of the globe. It is nearly allied to all the regular Monopetalous orders, with a capsular superior fruit, especially to *Solanaceæ* and *Ericaceæ*, from both of which it is readily known by the stamens being placed opposite to the segments of the corolla. In this respect it agrees with *Myrsinaceæ*, which differ chiefly in their fleshy fruit and arborescent habit. The Cowslip, *Primula veris*, from which a sedative wine is made; the Primrose, *Primula vulgaris*; Auricula, *Primula auricula*; and the acrid *Cyclamen*, together with *Anagallis*, or the herb Pimpernel, which regularly closes its flowers at the approach of rain, are species of this order, which in its various genera, and in *Primula* especially, yields us many beautiful garden flowers.

Primum Mobile (Lat.). In the Ptolemaic Astronomy, the outermost sphere of the universe, which gives motion to all the others (i. e. those of the moon, planets, &c.), and carries them round with it in its diurnal revolution. Its centre is the centre of the earth.

Primuries or **Primary Quills** (*Primores*, Linn.). The largest feathers of the wings; they rise from the pinion-bones, or those corresponding to the metacarpus and digits.

Prince (from the Latin princeps, *first* or *foremost*; the German equivalent, fürst, has the same etymological signification). In England, this title is applied only to members of the royal family; and in no case, except that of the eldest son of the reigning king (prince of Wales), is it connected with a territorial distinction. On the Continent, the rank of princes is various; in France, under the old régime, the title belonged only to certain families of high distinction, connected with the royal blood; it ranks in Germany below that of duke.

Prince of Wales. The title bestowed by patent on the heir apparent to the crown of England. The origin of the title of prince of Wales is as follows: When Edward I. subdued Wales, he promised the people of that country, upon condition of their submission, to give them a prince who was born amongst them, and who could speak no other language. Upon their acquiescence with this deceitful offer, he conferred the principality of Wales upon his second son Edward, then an infant, born within the principality, and unable to speak any language. Edward, by the death of his elder brother Alfonso, became heir to the crown, and from that time this honour has been appropriated to the eldest sons of the kings of England. The earldom of Chester, which is likewise usually conferred upon the heir-apparent, was once a principality, and erected into that title by parliament in the 21st of Richard II.; it was then appointed to be given to the king's eldest son. But the whole Acts of that parliament were repealed in the reign of Henry IV., although the earldom has usually been since given with the principality of Wales. The prince of Wales, being the sovereign's eldest son, is by inheritance duke of Cornwall during the life of the sovereign, without any new creation, and the revenue of the present prince of Wales is chiefly derived from the income of the duchy of Cornwall, which at present amounts to upwards of 60,000*l.* a year (net). The accumulations at the prince's majority exceeded 600,000*l.* By stat. 26 Vict. c. 1, an annuity of 40,000*l.* charged on the consolidated fund is provided for the prince of Wales during the joint lives of himself and the queen. To compass the death of the prince of Wales, or violate the chastity of his consort, is high treason within the statute of 25 Edw. III. The prince of Wales has a household of his own, of which the chief officers are a comptroller and treasurer, keeper of privy seal, groom of the stole, &c.; besides another class of officers belonging to the duchy of Cornwall. By a statute of the Order of the Garter, issued in 1805, the prince of Wales was declared a constituent part of the original institution. Hence every prince becomes a knight of the Garter the moment he is created prince of Wales. For the constitutional question raised in 1788, respecting the right of the prince of Wales to the regency, see REGENT.

Prince's Metal. Prince Rupert's metal. The same as pinchbeck. An alloy of copper and zinc, a variety therefore of *brass*. It consists of seventy-five parts of copper and twenty-five parts of zinc.

Princeps Senatus (Lat.). Prince or first of the senate. In ancient Rome, the citizen whose name was inscribed first on the list of the senate by the censors was so called. This high dignity was not connected with any office, and was conferred, in later times, only on those who were recognised as the most considerable citizens of the state. Before the second Punic war, it seems to have belonged of right to the oldest of those who had held the office of censor; but the first deviation from this practice was in favour of Fabius Maximus. This title was the first germ of the imperial authority of Augustus. [SENATE.] There is a memoir on the subject in vol. xxiv. of the *Mémoires de l'Académie des Inscriptions*.

Principal (Lat. principalis, *chief*). In Architecture, this term is applied to the assemblage of timbers that form the support of a roof; these are commonly known and spoken of as *a pair of principals*. It is also applied to the main timber in an assemblage of carpentry; thus, in a roof the strong rafters used for trussing the beams are called *principal rafters*.

PRINCIPAL. In the Fine Arts, the chief circumstance in a work of art, to which the rest are to be subordinate.

PRINCIPAL. The name by which the heads of the Scottish universities, and of several colleges at the English universities, are distinguished.

Principal Axes. Through any point o of a solid body or system of material particles, three mutually rectangular lines can be so drawn that, when chosen as coordinate axes, the sums $\Sigma m y z$,

Σmzx, Σmzy, extended to all particles m of the system, severally vanish. These lines are termed the *principal axes* at the point o, and they exist, whatever the form of the body may be, and wherever the point o may be situated; their directions, however, vary with the position of this point according to a very beautiful law. To explain this it will be necessary to recall a few properties of MOMENT OF INERTIA and RADII OF GYRATION. Of all the axes passing through a given point, the principal axes correspond to the greatest and least moments of inertia; they might, indeed, be defined as the axes corresponding to the critical values of such moments. When the point under consideration is the centre of gravity, the principal axes take the name of *central*. The ellipsoid whose centre coincides with the centre of gravity, whose principal semi-axes have the same directions as the central principal axes, and the same magnitudes as the radii of gyration relative to these axes, is termed the *central ellipsoid of gyration*, and the system of quadric surfaces confocal with it serves to define the directions of the principal axes at all other points in space. In fact, if through any point o the three quadrics be drawn which are confocal with the central ellipsoid of gyration, they will intersect one another orthogonally in curves which, at the point o, will have precisely the directions of the principal axes. The principal axes at a point o, therefore, coincide with the axes of the quadric cone which has its vertex at o, and is circumscribed to the central ellipsoid of gyration.

A line taken at random will not in general be a principal axis at any one of its points. If it be so at one of its points, the latter is then termed its *principal point*, and the line is necessarily normal to one of the confocal quadrics through that point. Every line parallel to a central principal axis has a principal point where it intersects the plane of the other two central principal axes. The central principal axes are characterised by the property of being principal at each of their points.

When a body is symmetrical with respect to three rectangular planes, the latter always intersect each other in principal axes. Thus the principal axes at the centre of a homogeneous ellipsoid coincide with its geometrical axes. In the case of a spheroid the axis of rotation is one principal axis, but the other two are indeterminate. In the case of the sphere any three orthogonal lines through the centre are principal axes. For further properties of principal axes, see the memoirs of Prof. W. Thomson and the Rev. R. Townshend in the *Cambridge and Dublin Mathem. Jour.* vol. i.

Principal Normal. [NORMAL, PRINCIPAL.]

Principes (Lat.). The name given to one of the grand divisions of the Roman infantry. It was their duty to assume the initiative in an engagement, and from this circumstance their name is said to be derived. The other three bodies were the HASTATI, TRIARII, and VELITES.

Principle (Lat. principium). In Chemistry, a term sometimes applied to certain proximate components of organic bodies, such as *bitter principle, febrifuge principle, narcotic principle*, &c. This term, however, is now almost disused, it having been found that each bitter, febrifuge, narcotic, or other substance, generally contains a principle peculiar to itself upon which its powers depend, and that there is no such common or universal principle as was formerly supposed. For the same reason the term *principle of inflammability*, or *phlogiston*, is rejected, as applied in common with *nervous principle*, &c., to an imaginary existence.

Principles. In the Fine Arts, those general and fundamental truths from which the rules and maxims of art are deduced. To each art particular principles are attached on which its theory is founded. These principles, before they can be said to have stability, must be found to depend on certain truths, which, recognised by everyone, and indisputable, oblige the mind to concur in the deductions that result from them.

Pringlea (after Sir John Pringle, who wrote on scurvy). The Kerguelen's-land Cabbage is the sole representative of this genus of *Cruciferæ*, and is called *P. antiscorbutica* on account of its properties. The plant has a thick rhizome, often three or four feet long, which lies along the ground and bears at its extremity a large cabbage, closely resembling the common cabbage of this country, having a dense white heart and loose green outer leaves. The whole plant abounds with an essential oil, and when cooked, the cabbage tastes like tough mustard and cress. Being a powerful antiscorbutic, it is invaluable to the crews of ships touching at Kerguelen's land. Dr. Hooker says: 'During the whole stay of the "Erebus" and "Terror" in Christmas Harbour, daily use was made of this vegetable, either cooked by itself or boiled with the ship's beef, pork, or pea-soup. The essential oil gives a peculiar flavour, which the majority of the officers and the crew did not dislike, and which rendered the herb even more wholesome than the common cabbage; for it never caused heartburn, nor any of the unpleasant symptoms which that plant sometimes produces.'

Printing (Fr. empreinte, imprimerie, typographie; Ger. Buchdrückerkunst). Letter-press printing, to which this article is confined, is the art of taking impressions from types and engravings in relief.

HISTORY.—The art of printing in Europe is of comparatively modern origin, only 400 years having elapsed since the first book, properly so called, issued from the press; but we cannot doubt that its rudiments were known to the ancients. It was certainly practised in the East from a very early period, and in a manner similar to our own first attempts. That a rude kind of printing was known to the Assyrians is evident from undecayed bricks which have been found stamped with various symbolical and hieroglyphic characters; but, as the stamp itself was in one piece or block, it

seems to have been inapplicable to the propagation of knowledge.

This primitive mode of printing is continued to the present time by the Chinese. Their earliest attempts are stated in the chronicles to have been made about fifty years before the Christian era; but it was not till the reign of the emperor Ming-tsong (927–934 A. D.) that any great advance was made in printing large numbers of comparatively cheap books. The name of the printer was Tong-tao. He obtained permission of the emperor in 932 to print and circulate copies of the 'Classical Works' as they are called, by taking impressions from stone plates, the letters being cut into them, so that the impression on the paper was black, and the letters themselves were left white. This is still the case in all Chinese lithographic printing. Tong-tao, however, subsequently obtained the emperor's sanction to cut in wood and print an edition of the nine 'King,' or classical books, for the use of the imperial college in Pekin. This was completed in 952; and, although intended only for the pupils of the college, it was allowed to be purchased by any person in the empire. The process pursued in the printing of this work is precisely the same as that which is practised at the present day; the following being the modus operandi: The work intended to be printed is handed to a calligraphist, who writes the separate pages on fine tracing paper; these are given to the engraver, who glues them face downwards upon a thin plate of hard wood, called *li*, resembling that of the pear-tree, and he cuts away with a sharp instrument all those parts of the wood on which nothing is traced, leaving the transcribed characters in relief and ready for printing. The Chinese printer then, having no notion of the printing press, makes use of two fine brushes, both held in the right hand, one of which contains ink, the other being dry. With the former he blackens the letters; the latter he passes gently over the paper which has been laid on them. By this means an expert workman can take a large number of impressions in one day. As the Chinese paper is thin and transparent, it is printed on one side only, two pages side by side, and the sheet has a black line down the middle, as a guide to the binder, who folds it double and fastens the open leaves together. Various attempts have been made in the Celestial Empire to substitute movable types for the wooden blocks, but they have always terminated in a return to the old method.

The ancient Romans made use of metal stamps, with characters engraved in relief, to mark their articles of trade and commerce; and Cicero, in his *De Naturâ Deorum*, has a passage from which Toland imagines the moderns have taken the hint of printing. Cicero orders the types to be made of metal, and calls them *formæ literarum*, the very words used by the first printers. In Virgil's time, too, brands, with letters, were used for marking cattle, &c., with the owner's name. Landseer, in his *Lectures on the Art of Engraving*, 8vo. 1807, observes, 'Had the modern art of making paper been known to the ancients, we had probably never heard the names of Faust and Finiguerra; for with the same kind of stamps which the Romans used for their pottery and packages, books might also have been printed; and the same engraving which adorned the shields and pateras of the more remote ages, with the addition of paper might have spread the rays of Greek and Etrurian intelligence over the world of antiquity. Of the truth of this assertion I have the satisfaction to lay before you the most decided proofs, by exhibiting engraved Latin inscriptions, both in cameo and intaglio, from the collection of Mr. Douce, with impressions taken from them at Mr. Savage's letter-press but yesterday [1805]. One of them is an intaglio stamp with which a Roman oculist was used to mark his medicines; the other, which is of metal, and in cameo, is simply the proper name of the tradesman by whom it has probably been used, "T[iti] Valagini Mauri."' The cut exhibits a fac-simile of the latter stamp.

Books before the Invention of Printing.—The value of books, and the esteem in which they were held before the invention of printing, were such, that notaries were employed to make the conveyance with as much care and attention as if estates were to be transferred. It was then thought the worthy occupation of a life either to copy or collect an amount of reading which modern improvements now present to us for a few shillings. Galen tells us that Ptolemy Philadelphus gave the Athenians fifteen talents, with exemption from all tribute, and a great convoy of provisions, for the autographs and originals of the tragedies of Æschylus, Sophocles, and Euripides. 'Pisistratus is said to have been the first among the earliest of the Greeks who projected an immense collection of the works of the learned, and is supposed to have been the collector of the scattered works which passed under the name of Homer.' (D'Israeli, *Cur. of Lit.*)

Among the Romans the bulk or goodness of a man's library was the distinguishing mark of his excellence and wisdom. Middleton (*Life of Cicero*), speaking of Cicero, says, 'Nor was he less eager in making a collection of Greek books, and forming a library, by the same opportunity of Atticus's help. This was Atticus's own passion; who, having free access to all the Athenian libraries, was employing his slaves in copying the works of their best writers, not only for his own use, but for sale also, and the common profit both of the slave

and the master; for Atticus was remarkable, above all men, for a family of learned slaves, having scarce a foot-boy in his house who was not trained both to read and write for him. By this advantage he had made a very large collection of choice and curious books, and signified to Cicero his design of selling them; yet seems to have intimated withal, that he expected a larger sum for them than Cicero would easily spare; which gave occasion to Cicero, to beg of him in several letters, to reserve the whole number for him, till he could raise money enough for the purchase. "Pray keep your books (says he) for me, and do not despair of my being able to make them mine; which if I can compass, I shall think myself richer than Crassus, and despise the fine villas and gardens of them all." Again, "Take care that you do not part with your library to any man, how eager soever he may be to buy it; for I am setting apart all my little rents to purchase that relief for my old age."'

In the year 1274 the price of a Bible, in 9 volumes, 'fairly written,' with a glossary or commentary, was 50 marks, or 33*l.*; and in 1433, the cost of transcribing the works of Nicholas de Lira, in 2 vols., 'to be chained in the library of the Grey Friars,' London, was 66*l.* 13*s.* 4*d.* This shows the enormous cost of books before the discovery of printing; for, if we take the money of those times to be twenty times its present value, the Bible must have been worth 660*l.*, and De Lira 1,333*l.* 6*s.* 8*d.* The pay of a labouring man in 1272 was 1½*d.* a day. (Dugdale's *Warw.*; Stow; Rymer's *Fœdera.*)

Among other writers on this subject, Mr. Watson, in his *History of Printing*, refers us to an epistle of Antonius Bononia Becatellus, surnamed Panorme, to Alphonsus king of Naples and Sicily, lib. v. Epist. *Significasti mihi nuper ex Florentia, &c.* 'You lately wrote to me from Florence, that the works of Titus Livius are there to be sold, in very handsome books; and that the price of each book is 120 crowns of gold: therefore I intreat your majesty, that you cause to be bought for us Livy, whom we use to call the king of books, and cause it to be sent hither to us. I shall in mean time procure the money, which I am to give for the price of the book. One thing I want to know of your prudence, whether I or Poggius have done best; he, that he might buy a country-house near Florence, sold Livy, which he had writ in a very fair hand; and I, to purchase Livy, have exposed a piece of land to sale: your goodness and modesty have encouraged me to ask these things with familiarity of you. Farewell, and triumph.'

Nor was it in Italy alone that books were valued at immense prices, but in France also, as appears by a letter of Gaguin to one of his friends who had sent to him from Rome to procure a Concordance for him: 'I have not to this day found out a Concordance, except one, that is greatly esteemed; which Paschasius, the bookseller, has told me is to be sold, but the owner of it is abroad; and it may be had for a hundred crowns of gold.' Mr. Ames had a folio manuscript in French verse called *Romans de la Rose* (whence Chaucer's translation), on the last leaf of which is written, *Cest lyuir costa au palas de Parys quarante coronnes dor, sans mentyr*; i.e. This book cost at the palace of Paris 40 crowns of gold, without lying (about 33*l.* 6*s.* 6*d.* sterling).

Brassicanus says, 'The emperor Frederick III. knew no better gratuity for John Capnion, who had been sent to him on an embassy by Edward of Wittemberg, tha' by making him a present of an old Hebrew Bible.'

Another instance of the high estimation in which books were held in old times, is to be seen in the front of the manuscript Gospels belonging to the public library of the university of Cambridge, written in an old hand in Latin and Anglo-Saxon, given to the university by the learned Theodore Beza. 'This book was presented by Leofric, bishop of the church of St. Peter's in Exeter, for the use of his successors.' This Leofric was chancellor of England in the reign of Edward the Confessor, and died in 1071 or 1072.

About the time of King Henry II. the manner of publishing books was to have them read over for three days successively before one of the universities, or before other judges appointed by the public; and, if they met with approbation, copies of them were then permitted to be taken. These copies were usually written by monks, scribes, illuminators, and readers brought or trained up to that purpose for their maintenance. The orders respecting books in the 'Close Rolls' of the middle ages are interesting, not only as illustrating the literary taste of the age, but principally because they generally contain some circumstance which shows the scarcity and value of the article.

The passion for the enjoyment of books has in all ages led their lovers to cover them with the most costly and ornamental bindings. The ancients commonly adorned them with pendent ornaments of variously coloured cloth, and the covers were stained with scarlet or purple colour: 'Hirsutus sparsis ut videare comis' (*Ovid*), and 'Purpureo fulgens habitu, radiantibus uncis' (*Martial*). The *unci* were rollers of wood or ivory, round which the books were rolled to prevent injury to their fronts. Ovid and Tibullus call them *cornua*, from the similarity of their ends to horns. Epistles differed from books in this: the leaves were folded together, tied round with linen tape, and sealed with *creta Asiatica*, while books were 'bound' as above. If, however, there were more epistles than one, 'or if one epistle was to be preserved in the library, it was enclosed and turned round, and not folded: hence the word *volumen*' (*Arts of the Greeks and Romans*).

Block Books.—Block books must be regarded as the immediate precursors of printing. The art of printing books from engraved blocks of wood was without doubt invented in Holland. Apart from the great interest created by the

object for which the block books were designed, namely, the propagation of the Scriptures, they are extremely valuable as exhibiting the first attempts at engraving on wood in the form of books, many of them having preceded the art of printing by movable types. (Sotheby's *Block Books.*)

That prints without text, or *letterpress*, as it is termed, were in common use at a period considerably anterior to that of the block books, there is abundant evidence. It is related by Papillon (*Traité Historique et Pratique de la Gravure en Bois*) that the heroic actions of Alexander the Great were engraved on wood by the two Cunio, Alexander Alberic, and his sister Isabella, and impressions printed from tho blocks, as early as 1285; and his statement has been supported by Ottley (*Early Hist. of Engraving upon Copper and Wood*, &c. 2 vols. 4to. 1816) and Singer (*Hist. of Playing Cards, &c.* London, 4to. 1816). But Jackson (*Hist. of Wood Engraving*) takes some trouble to prove that Papillon was excessively credulous, if not deranged. Playing cards were engraved and printed from blocks towards the end of the fourteenth century or probably earlier. The print of St. Christopher carrying the infant Saviour on his back across the sea, in the collection of Earl Spencer, bears an inscription and the date 1423 at the bottom of the same block; but one in the possession of Mr. J. A. O. Weigel of Leipsic (a copy of which may be seen in Sotheby's *Block Books*, vol. ii. p. 161), is supposed to be the work of even an earlier artist. These circumstances, together with the fact that the government of Venice published a decree, dated October 11, 1441, wherein the art and mystery of making 'playing cards and coloured figures printed' are stated to have fallen into decay in consequence of the great quantity which had been made out of that state, and which were now prohibited under pain of forfeiture and fine, all prove that the knowledge and practice of printing, although not applied to the spread of knowledge and the multiplication of books, had yet an existence in Europe long before the time to which it is usually attributed. This Venetian decree may be regarded as the earliest authentic document respecting printing.

Great numbers of books were produced in the Chinese manner above described: for the diversity of the characters found in block books has been a never-ending puzzle to those who have endeavoured to ascertain the printer by comparing the forms of the letters used. The workmanship of many of these picture books was coarse, without shadowing or 'cross-hatching,' tastelessly daubed over with broad colours, especially those which were printed for circulation amongst the poorer classes. The best known works of this class were called *Biblia Pauperum*, poor men's books, or rather books for poor preachers, and consisted of a series of rude engravings, each occupying a page on one side of the leaf only, and divided into compartments containing pictorial illustrations of the most remarkable incidents mentioned in the books of Moses, the Gospels, and the Apocalypse. A copy of the *Biblia Pauperum* in the British Museum is supposed by Heinecken (*Idée Générale, &c.* p. 292) to be the first edition. The cuts are coloured by hand.

Invention of Movable Types.—About the year 1438, while the learned Italians were eagerly deciphering their recently discovered MSS., and slowly circulating them from hand to hand, it fell to the lot of a few obscure Germans to perfect the greatest discovery recorded in the annals of mankind. The notion of printing by movable types, and thereby saving the endless labour of cutting new blocks of letters for every page, was reserved for John Gutemberg of Mentz. Born in that city about the beginning of the century, he settled at Strasburg about 1424, and commenced printing in the house of one Dritzehen. But having been engaged in a lawsuit connected with Dritzehen's family, and exhausted his means, he returned to Mentz, where he resumed his typographic employment in partnership with a wealthy goldsmith, named John Fust or Faust. After many experiments with his presses and movable types, Gutemberg succeeded in printing an edition of the Vulgate, the Mentz or Mazarin Bible, so called from a copy having been discovered in the library of Cardinal Mazarin in Paris. The work was done between the years 1450 and 1455, and was printed on vellum; but there are several paper copies in England, France, and Germany. The partnership between Gutemberg and Fust having been dissolved, and the former being unable to repay part of the capital advanced by the wealthy goldsmith, the whole of the printing apparatus fell into the hands of Fust, who, says D'Israeli (*Cur. of Lit.*), 'printed off a considerable number of copies of the Bible, to imitate those which were commonly sold as MSS.; and he undertook the sale of them at Paris. It was his interest to conceal this discovery, and to pass off his printed copies for MSS. But, enabled to sell his Bibles at sixty crowns, while the other scribes demanded five hundred, this raised universal astonishment; and still more when he produced copies as fast as they were wanted, and even lowered his price. The uniformity of the copies increased the wonder. Informations were given in to the magistrates against him as a magician; and in searching his lodgings a great number of copies were found. The red ink—and Fust's red ink is peculiarly brilliant—which embellished his copies, was said to be his blood; and it was solemnly adjudged that he was in league with the infernals. Fust at length was obliged, to save himself from a bonfire, to reveal his art to the parliament of Paris, who discharged him from all prosecution in consideration of the wonderful invention.' This Bible was printed with large *cut* metal types; but in 1457 a magnificent edition of the *Psalter* appeared, printed by Fust and his assistant and son-in-

law, Peter Schœffer, who had been taken into partnership. In this book the new invention was announced to the world in 'a boasting colophon,' though certainly not unreasonably bold. Another edition of the *Psalter*, one of an ecclesiastical book, Durand's account of liturgical offices (*Rationale Divin. Officiorum*), one of the Constitutions of Pope Clement V., and one of a popular treatise on general science, called the Catholicon (*Catholicon Januensis*, *1460*), filled up the interval till 1462, when the second Mentz Bible proceeded from the same printers. This, in the opinion of some, is the earliest book in which *cast* metal types were employed: those of the Mazarin Bible having been cut with the hand. But this is a controverted point. In 1465 Fust and Schœffer published an edition of Cicero's *Offices*, the first tribute of the new art to polite literature. (Hallam, *Europe during the Middle Ages*, vol. iii. p. 470.)

After the lapse of a few years the pupils and workmen of Fust and Schœffer were dispersed into various countries by the sacking of Mentz under the Archbishop Adolphus, and the invention was thereby publicly made known, and the art spread over all parts of Europe. Before the year 1500, printing presses had been set up in 220 places, and a multitude of editions of the classical writers given to the world. From Mentz the art was transplanted to Haarlem and Strasburg; from Haarlem to Rome, in 1466, by Sweynheym and Pannartz, who were the first to make use of Roman types; to Paris in 1469; to England in 1474; and to Spain in 1475. So rapid indeed was the spread of the art, that, between the years 1469 and 1475, most towns in Germany, Italy, and the Netherlands had made successful attempts in the production of printed copies of the most valued authors of the time. Santander, in his interesting and masterly work, *Dictionnaire Bibliographique choisi du Quinzième Siècle, &c.* (Bruxelles 1805, 3 vols.), gives at the end of his first volume, the following chronological table of 200 places where the art was practised during the fifteenth century, with the names of the printers and of the first productions of their presses. This table is given, not only because it is curious, but because bibliographers are enabled to see at a glance the editiones principes of the fifteenth century.

Chronological Table of the Towns, Monasteries, &c. in which the Art of Printing was practised in the Fifteenth Century; giving the first portion of the Titles of the First Impressions, with their Date in each Place, together with the Printers' Names.

N.B.—The Figures in Parentheses indicate the Date of the Impressions in which the Printer's Name appears for the First Time.

Dates	Names of Towns, &c.	First Impression with Certain Date	Names of the First Printers
1457	Mentz	Psalmorum codex, folio	Joan. Fust et Petrus Schœffer.
1461	Bamberg	Recueil de fables, germanicè, folio	Albert Pfister.
1465	Subbiaco	Lactantii opera, 4to	Conradus Sweynheym et Arnoldus Pannartz.
1467	Rome	Ciceronis epistolæ ad familiares, 4to	The same printers.
1467	Elfeld	Vocabularium ex quo, 4to	Henry et Nic. Bechtermuntze et Wigandus Spyes.
1467	Cologne	S. August. de Singul. clericor., 4to	Ulricus Zell, or Zell d'Hanau.
1468	Augsburg	Meditationes vitæ Christi, folio	Ginther Zainer, de Reutlingen.
1469	Venice	Ciceronis epistolæ ad familiares, folio	Joannes de Spira.
1469	Milan	Miracoli de la glor. V. Maria, 4to	Philippus de Lavagna.
1470	Nuremberg	Comestorium vitiorum, folio	Joannes Sensenschmidt (1472).
1470	Paris	Epistolæ Gasparini Pergamensis, 4to	Ulricus Gering, M. Crantz et M. Friburger, de Colmar.
1470	Foligno	Leon. Aretini de Bello Italico, folio	Emilien de Orfinis.
1470	Treves	Hist. de indulgentia B. Francisci, 4to	Joan. Reynardi.
1470	Verona	La Batracomyomachia, folio	Joan de Verona (1472).
1471	Strasburg	Gratiani decretum, folio	Joan. Mentelius (1473).
1471	Spires	Postilla super Apocalypsim, 4to	Petrus Drach (1477).
1471	Treviso	Mercurius Trismegistus, 4to	Gerardus de Lisa, de Flandria.
1471	Bologna	Ovidii opera, folio	Balthasar Azzoguidi.
1471	Ferrara	Martialis epigram, 4to	Andreas Belfortis.
1471	Naples	Bartholi de Saxo Ferrato lectura, folio	Sixtus Riessinger, de Strasburg.
1471	Pavia	Joann. Matthæi de Gradibus opera medica, folio	Anton. de Carcano (1476).
1471	Florence	Comment. Servii in Virgil., folio	Bernard Cennini and son.
1472	Cremona	Angeli de Perusio lectura, folio	Dion. de Paravesino et Steph. de Merliniade Leucho.
1472	Fivizano	Virgilius, folio	Jacobus, Baptista Sacerdos et Alexander.
1472	Padua	La Fiammetta di Boccaccio, 4to	Barth. de Valdesochio et Mart. de Septem Arboribus.
1472	Mantua	Tractatus Maleficiorum, folio	Petrus-Adam de Michaelibus.
1472	Montereale	S. Antonini de instruct. confes., 4to	Ant. Mathiæ de Antuerpia et Balthasar Corderius.
1472	Jesi	Commedia di Dante, folio	Fridericus Veronensis.
1473	Munster, in Argau	Roderici speculum, folio	Helias Helye, or de Louffen.
1473	Parma	Trionfi di Petrarca, folio	Andreas Portiglia.
1473	Brescia	Statuta Brixiæ, folio	Thomas Ferrandus.
1473	Messina	Vita di S. Hieronimo, 4to	Henricus Alding.
1473	Ulm	Opus de mysterio missæ, 4to	Joan. Zainer, de Reutlingen.

Dates	Names of Towns, &c.	First Impression with Certain Date	Names of the First Printers
1473	Buda	Cronica Hungarorum, folio	Andreas Hess.
1473	Laugingen	S. Aug. de Consensu Evangelistarum, fol.	No printer's name.
1473	Mersburg	S. Aug. de Quæstionibus Orosii, 4to	Lucas Brandis.
1473	Alost	Speculum conversionis peccator., 4to	Theodoricus Martens.
1473	Utrecht	Historia scholastica novi Testam., folio	Nicolas Ketelaer et Ger. de Leempt.
1473	Saint Ursio	J. Duns Scotus super tertio sententiarum, folio	Joannes de Rheno.
1474	Vicenza	Dita mundi, folio	Leonardus Achates, de Bâle.
1474	Como	Tractatus de appellationibus, folio	Ambrosius de Orcho et Dionys. de Paravicino.
1474	Turin	Breviarium romanum, 8vo	Joh. Fabri et Joanninus de Petro.
1474	Genoa	Summa Pisanella, folio	Matthias Moravus et Mich. de Monaco.
1474	Savona	Boëthius de Consol. philosophiæ, 4to	Bonnus Johannes.
1474	Eslingen	Th. de Aquino in Job., folio	Conradus Fyner.
1474	Basle	Der Sassen Spiegel, folio	Bernardus Richel.
1474	Val Sainte Marie	Breviarium Moguntin., 4to	Fratres Vitæ Communis.
1474	Valencia	Trobes de la S. V. Maria, 4to	Alonso Fernandez de Cordova et L. Palmart (1478).
1474	Louvain	Commoda ruralia, folio	Joannes de Westphalia.
1474	Westminster	The Game and Playe of the Chesse, folio	William Caxton.
1475	Lubeck	Rudimentum Novitiorum, folio	Lucas Brandis, de Schass.
1475	Burgdorff	Tractatus de apparitionibus, folio	No printer's name.
1475	Blauburren	Ob ein Man sey zu nemen Weib, &c.	Conradus Mancz.
1475	Cagli	Mafei Vegii, de Morte Astyanactis, 4to	Robertus de Fano et Bernardinus de Bergamo.
1475	Casole	Vitæ Sanctorum, 4to	Jean Fabri.
1475	Modena	Virgilius, folio	Joan. Vurster, de Campidonia.
1475	Perugia	Verulami, de Arte grammatica, 4to	Henricus Clayn. de Ulm (1476).
1475	Pieve di Sacco	Quatuor ordines, hebraicè, folio	R. Mesculam, dit Kotzi.
1475	Piacentia	Biblia latina, 4to	Joan. Petrus de Ferratis.
1475	Reggio	R. Salomon Jarchi in Pentateuchum, fol.	Abraham Garton.
1475	Barcelona	Valasti de Tarenta, de Epidemia, 4to	Nicolaus Spindeler (1481).
1476	Antwerp	Thesaurus pauperum, folio	Theodoricus Martens, d'Alost.
1476	Bruges	Bocace, du déchiet des nobles, &c., folio	Colard Mansion.
1476	Brussels	Gnotosolitos, folio	Fratres Vitæ Communis.
1476	Nova Pilzna	Statuta synodalia Pragensia, 4to	No printer's name.
1476	Rostock	Lactantii opera, folio	Fratres Vitæ Communis.
1476	Pogliano	Petrarca, degli huomini famosi, 4to	Innocentius Ziletus et Felix Antiquarius.
1476	Trent	De obitu pueri Simonis, 4to	Hermannus Schindeleyp.
1476	Lyons	Legende de Jac. de Vorages, folio	Barthol. Buyer.
1477	Delft	Biblia, belgicè, folio	Jacob Jacobs et Maurice Yemants.
1477	Deventer	Reductorium Bibliæ, folio	Richard Paffroet.
1477	Gouda	Epistelen en evangelien, folio	Gerard Leeu, or Leew.
1477	Angers	Manipulus curatorum, folio	Joan. de Turre et Joan. Morelli.
1477	Palermo	Consuetudines Panormi, 4to	Andreas de Wormatia.
1477	Ascoli	Cronica de S. Isidoro Menore, 4to	Gulielmus de Linis.
1477	Lucca	Les triomphes de Pétrarque, folio	Barthol. de Civitali.
1477	Seville	Sacramentale, 4to	A. M. de la Talla, B. Segura et Alonso del Puerto.
1478	Cosenza	Dell' immortalità dell' anima, 4to	Octavianus Salomonius de Manfredonia.
1478	Colle	Dioscorides, latinè, folio	Joannes Alemanus, de Medemblick.
1478	Chablis	Des bonnes mœurs, folio	Pierre le Rouge.
1478	Geneva	Le livre des Saints Anges, folio	Adam Steynschawer, de Schuinfordia (1480).
1478	Oxford	Expositio in simbolum, 4to	Theodore Rood.
1478	Prague	Statuum utraquisticorum articuli, folio	No printer's name.
1478	Monast. Sorten	Leonardi Aretini comœdia, &c., folio	No printer's name.
1478	Eichstett	Summa hostiensis, folio	Michel Reyser.
1479	Wurtzburg	Breviarium herbipolense, folio	Stephanus Dold, Jeorius Ryser et Joan. Bekenhub.
1479	Zwoll	Summulæ Petri Hispani, folio	Joannes de Vollehoë.
1479	Nimeguen	Epistola de privilegiis Ord. Mendicant, 4to	No printer's name.
1479	Pignerol	Boëthius, de Consol. philosophiæ, folio	Jacobus de Rubeis.
1479	Tusculano	Æsopi fabulæ, 4to	Gabriel Petri.
1479	Toulouse	Tractatus de Jure emphyteutico, folio	Joannes Teutonicus.
1479	Poitiers	Breviarium historiale, 4to	Joan. Bouyer et Guillaume Bouchet (1499).
1479	Segorba	Constitutiones synodales, folio	No printer's name.
1480	Oudenarde	Herm. de Petra Sermones, folio	Arnoldus Cesaris.
1480	Hasselt	Epistelen en Evangelien, 4to	No printer's name.
1480	Nonantola	Breviarium romanum, 4to	Georgius et Anselmus de Mischinis.
1480	Reggio	Nic. Perotti Rudim. gram., 4to	Barthol. et Laurentius de Bruschis.
1480	Friuli	Platina de honesta voluptate, 4to	Gerardus de Flandria.
1480	Caen	Horatii epistolæ, 4to	Jac. Durandus et Egidius Quijoue.
1480	Saint Albans	Laur. Guil. de Saona, Rhetorica nova, 4to	No printer known.
1481	Leipsic	Glosa super apocalipsim, 4to	Marcus Brand (1484).
1481	Casal	Ovidii Epist. heroides, folio	Guill. de Canepa Nova, de Campanilibus.
1481	Urbino	Marii Philelphi Epistolarium, 4to	Henricus de Colonia (1493).
1481	Vienne, in France	Nic. de Clemangis de Lapsu justitiæ, 4to	Pierre Schenck.
1481	Aurach	Leben der Heiligen, folio	Conradus Fyner.
1482	Aquila	Vite di Plutarcho, folio	Adam Rotwil, Alemannus.
1482	Erfurt	Quæstiones in libros Arist de anima, 4to	Paulus Wider de Hornbach.
1482	Memmingen	Fasciculus temporum, folio	Albertus Kunne.
1482	Passau	Epistola de Morte S. Hieronimi, 4to	Conradus Stahel, et Bened. Mayr.
1482	Reutlingen	Summa Pisani, folio	Johan. Ottmar.

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1482	Vienna, in Austria	Manipulus Curatorum, 4to . . .	Joh. Winterburg (1492).
1482	Promentour .	Doctrinal de Sapience, folio . . .	Louis Guerin.
1483	Magdeburg .	Officium Missæ, 4to	Albertus Rauenstein et Joachimus Westval.
1483	Stockholm . .	Dialogus creaturarum, 4to . . .	Joh. Snell.
1483	Ghent . .	Guil, Rhetorica divina, 4to . . .	Arnoldus Cæsaris.
1483	Troyes . .	Breviarium Trecence, 8vo . . .	Guil. le Rouge (1492).
1483	Schiedam . .	Le chevalier Delibere, 4to . . .	No printer known.
1483	Haarlem . .	Formulæ Novitiorum, 4to . . .	Joh. Andriesson.
1483	Culemburg . .	Speculum human. salv., belgicè, 4to .	Jean Veldener.
1483	Leyden . .	De Cronike van Holland, &c., 4to . .	Heynricus Heynrici.
1483	Pisa . . .	Franc. de Accoltis consilia, folio . .	Laurentius et Angelus Florentini (1484).
1484	Bois-le-Duc .	Tondalus Vysioen, 4to	Ger. Leempt, de Novimagio.
1484	Winterberg .	Albertus Magnus de Eucharistia . .	Joannes Alacraw.
1484	Chambéry . .	Baudoyn, comte de Flandres, folio .	Antonius Neyret.
1484	Breand-Loudéhac	Le Songe de la Pucelle, 4to . . .	Robin Foucquet.
1484	Rennes . .	Coustumes de Brétagne, 12mo . .	Pierre Belleesculée et Josses.
1484	Sienna . .	Paul. de Castro, lectura, folio . .	Henri de Colonia.
1484	Soncino . .	Delectus Margaritarum, hebraicè, 4to .	Josuas Salomon and associates.
1484	Novi . . .	Summa Baptistiniana, 4to . . .	Nicol. Girardengus.
1485	Heidelberg .	Hugonis Sermones, folio . . .	Fridericus Misch (1488).
1485	Ratisbon . .	Liber Missalis Ratisbonnensis, folio .	Joan. Sensenschmidt et Beckenhaub.
1485	Vercelli . .	Nic. de Auxmo suppl. sum. Pisan., 8vo	Jacobinus Suigus de S. Germano.
1485	Pescia . .	La Confessione de S. Bern. da Sienna, 4to	Franc. Cenni.
1485	Udino . . .	Nic. Perotti Rudim. grammat., 4to .	Gerardus de Flandria.
1485	Burgos . .	And. Guterii opus Grammatic., folio .	Fridericus de Basilea.
1485	Zaragoza . .	Epistolas y Evangelios, folio . . .	Paulus Hurus.
1485	Salamanca . .	Medicinas de la Peste, 4to . . .	Antonius de Barreda (1498).
1486	Abbeville . .	La Cité de Dieu de S. Aug., folio . .	Jean Dupré et Pierre Gérard.
1486	Brunn . .	Agenda Chori Olomucensis, 4to . .	Conradus Stahel et Mattheus Preinlein (1491).
1486	Munster . .	Rudolphi Langi Carmina, 4to . .	Joannes Limburgus.
1486	Schleswig . .	Missale Sleswicence, folio . . .	Stephanus Arndes.
1486	Casale Maggiore	Machasor, hebraicè, 4to	No printer known.
1486	Chivasio . .	Angeli de Clavasio summa, 4to . .	Jacobinus Suigus.
1486	Voghera . .	Alex. de Immola postillæ, folio . .	Jacobus de Sancto-Nazario.
1486	Toledo . .	Petri Ximenez confutatorium, 4to . .	Joannes Vasqui (Vazquez).
1487	Besançon . .	Liber de Pestilensia, 4to . . .	Jean Comtet.
1487	Gaeta . .	Formulario epistolare, 4to . . .	A. F. (Andreas Fritag).
1487	Valeria . .	El Valerio de las hist. de Espana, folio .	Jean de Roca.
1487	Rouen . .	Croniques de Normandie, folio . .	Guillaume le Talleur.
1487	Ischar (Ixar) .	II. Ordo Arba Turim, hebraicè, folio .	Eliezer, filius Alanta.
1488	Tarragona . .	El conde Partenoples, 8vo . . .	Joan. Rosembach (1499).
1488	Viterbo . .	Servii honorati de Metrorum Gener, 8vo	No printer known.
1489	Hagenau . .	Cornutus Joan. Garlandia, 4to . .	Henricus Gran.
1489	Kuttenberg .	Biblia, Bohemicè, folio	Martin Van Tischniowa.
1489	Lerida . .	Petri de Castrovol, in libros nat. Arist., folio	No printer known.
1489	S. Cucufate .	El Abad Isaoh de Religione, 4to . .	No printer known.
1489	Lisbon . .	Rabbi M. Nachmanidis in Pent., folio .	Samuel Zorba et Raban Eliezer.
1490	Orleans . .	Manipulus curatorum, 4to . . .	Matthieu Vivian.
1490	Ingolstadt . .	Rosarium celestis curiæ, folio . .	Joan. Kachelofen.
1490	Porto . .	Statuta commun. Ripperiæ, folio . .	Barthol. Zanni.
1490	Zamora . .	Los Evangelios desde Adviento, &c., folio	No printer known.
1491	Dijon . . .	Cisterc. ord. privilegia, 4to . . .	Petrus Metlinger.
1491	Angoulême .	Auctores VIII., Cato, Facetus, &c., 4to	No printer known.
1491	Hamburg . .	Laudes B. M. Virg., folio . . .	Joh. et Thomas Borchard.
1491	Nozani . .	P. Turretini disputatio Juris, folio .	Henri de Colonia et Henri d'Harlem.
1492	Dôle . . .	Joan. Heberling de Epidemia, 4to . .	No printer known.
1492	Leiria . . .	Proverbia Salom., hebraicè, folio . .	Abraham Dortas.
1492	Zinna . . .	Psalterium B. M. V., 4to . . .	No printer known.
1493	Alba . . .	Alex. de Villa doctrinale, folio . .	No printer known.
1493	Clugni . .	Missale Cluniacense, folio . . .	Michael Wenssler.
1493	Friburg . .	S. Bonav. in IV. sentent., folio . .	Kilianus Piscator.
1493	Luneburg . .	Th. à Kempis, de Imit. Christi, 8vo .	Joan. Luce.
1493	Nantes . .	Les Lunettes des Princes, 8vo . .	Etienne Larcher.
1493	Copenhagen .	Regulæ de fig. construct. grammat., 4to	Gothofridus de Ghemen.
1494	Oppenheim .	Wigandi Wirt Dialogus apolog., &c., 4to	No printer known.
1495	Forli . . .	Nic. Ferretti de Elegantia linguæ latinæ servanda, 4to	Hieronymus Medesanus.
1495	Freisingen . .	Compendiosa mat. pro Juven. inform., 4to	Joan. Schaeffler.
1495	Limoges . .	Breviarium Lemovicence, 8vo . .	Joan. Berton.
1495	Scandiano . .	Appianus, folio	Peregrinus de Pasqualibus.
1495	Schoenhoven .	Breviarium Trajectense, folio . .	No printer known.
1496	Barco . .	Selicoth, hebraicè, folio	Gerson Mentzlen.
1496	Offenburg . .	Quadragesimale de Litio, 4to . . .	No printer known.
1496	Provins . .	La Règle des Marchands, 4to . . .	Guill. Tavernier.
1496	Tours . . .	La vie de St. Martin, folio . . .	Matthieu Lateron.
1496	Pampeluna .	Petri de Castrovole sup. lib. Yconom. Arist., folio	Arnaldus Guillen.
1496	Granada . .	Franc. Ximenes de Vita Christ, folio .	Menardus Ungut.
1497	Avignon . .	Luciani Palinurus, &c., 4to . . .	Nicol. Lepe.
1497	Carmagnola .	Facini Tibergæ in Alex. de villa, &c. .	No printer known.
1498	Tubingen . .	Pauli lectura in primum Senten., folio .	Jean. Ottmar.

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1490	Tregnier	Le Catholicon, folio	No printer known.
1499	Montserrat	Missale Benedictinum, folio	Joan. Luchner Alemannus.
1500	Cracow	Ciceronis rhetor. libri IV., 4to	(Joannes Haller).
1500	Munich	Ang. Mundii oratio, 4to	Joannes Schobser.
1500	Olmutz	Aug. de Olomvox contra Waldenses, 4to	Conradus Bomgathem.
1500	Pfortzheim	Joan. Altenstaig vocabularius	Thomas Anselmus Badensis.
1500	Perpignan	Breviarium Elnense, 8vo	J. Rosembach de Heidelberg.
(1500)	Jaen, or Gien	Petri Dagui, tractatus de differentiis	No printer's name.
1475	Savillano	Manipulus curatorum, folio	Christoph. Beggiamo et J. Glim.
(1500)	Albia	Eneæ Sylvii de amoris remedio, 4to	No printer's name.
(1500)	Rhenen	Dat leeven van H. maget S. Kunera	No printer's name.

The first book in which Greek types occur is Cicero's *Offices*, printed in the year 1465, in which the characters are so imperfect that the words are with difficulty deciphered; but the first work printed wholly with Greek types is a Greek Grammar written by the learned Constantine Lascaris, printed in Milan by Dionysius Paravisinus, in 1476, in 4to. It went through several editions in Italy, France, and Switzerland. One of them, that of Aldus, printed in Venice in 1495, is the first Aldine book printed with a date. One of the most elegant specimens of ancient Greek typography, valued not only for its beauty, but also for its rarity and the accuracy of its text, is the *Argonautica*, Flor. ap. Junta, 1500, 4to. editio princeps. It was not unusual for the early printers of Greek as well as of other works, to endeavour to imitate the characters of the MSS. of the age. In this they were more or less successful. An exceedingly beautiful specimen of this kind of printing is the editio princeps of Isocrates, *Orat. à Demetrio Chalcondyla*, Gr. Mediol. ap. Henr. Germanus et Sebastianus ex Pontremula, 1493, fol. The text of this edition is said to be remarkably accurate. Fabricius considers it more exact than that of the Aldine edition of 1513. The first Greek book printed in Rome was *Pindari Opera*, Gr. cum Scholiis Calliеggi, Rome, 1515, 4to. This is also remarkable as the first edition with the Scholia. The first Greek work printed at Cambridge was Plato's *Menexenus, sive Funebris Oratio, exhortatio ad Patriam amandam atque defendendam*, Cantab. Greek types were not introduced into Scotland till after the middle of the sixteenth century. In a 4to. volume printed at Edinburgh in 1563, entitled, *The Confutation of the Abbote of Crosraguel's Masse*, there is an Epistle from the Printer to the Reader, apologising for his want of Greek characters, which he was obliged to supply by manuscript. The first work printed with Roman types was Cicero's *Epistolæ ad Familiares*, by Sweynheym and Pannartz, at Rome, in 1467. Italic type was invented by Aldus Manutius, about 1500. Italy has the honour also of having printed the first Hebrew Bible, at Soncino, a small city in the duchy of Milan, in 1488, under the superintendence of two Jewish rabbins, named Joshua and Moses. The edition of Brescia, of 1494, was used by Luther in making his German translation. But Hebrew types were not introduced into England for many years after this period; for we find that in 1524, Dr. Robert Wakefield, chaplain to Henry VIII., complains, in his *Oratio de Laudibus*, &c., that he was obliged to omit his whole third part, as the printer (Wynkyn de Worde) had no Hebrew types. Towards the end of the sixteenth century, various works were printed in Syriac, Arabic, Persian, Armenian, and Coptic, or modern Egyptian types; some to gratify the curiosity of the learned, and others for the liturgic uses of the Christians in the Levant.

Printing in England.—Until about the period of the Restoration, William Caxton was universally acknowledged to have introduced the art of printing into this country, in or about the year 1471. But, in 1664, Richard Atkyns, in a work called *The Original and Growth of Printing, &c.*, brought before the notice of the curious a little book, printed at Oxford, bearing the date 1468, three years before the period usually assigned to the labours of Caxton. This work took literary men by surprise, and gave rise to the most violent discussions. It is related by Atkyns that a Dutchman of the name of Frederic Corsellis was induced to desert his employers in the Low Countries, and that one Richard Turnour, an agent of King Henry VI., assisted by William Caxton, who was well known in Holland as a merchant and therefore likely to throw the jealous possessors of the new art off their guard, brought him to England, where at Oxford he was set to work by Archbishop Bourchier, ten years before the date of Caxton's first book. The title of Corsellis' volume is *Exposicio Sancti Jeronimi in Simbolum Apostolorum ad Papam Laurentiam*. And at the end *Explicit Exposicio, &c.* Impressa *Oxoniæ, et finita anno Domini* MCCCCLXVIII. XVII. *die Decembris*. The silence of Caxton, however, on a subject in which he took the utmost interest, and on a transaction in which he is said to have been an important actor, is a strong argument against the authenticity of the story. Indeed, M. Santander (vol. i. p. 328) does not for a moment entertain the pretensions of Corsellis, and agrees with Dr. Middleton in considering that the date MCCCCLXVIII. ought to have been MCCCCLXXVIII., an X having been by accident omitted by the compositor: 'Voilà ce que Richard Atkyns imagina, et les moyens dont il se servit, en 1664, pour soutenir contre le corps des libraires de Londres, que l'imprimerie était un droit de la

couronne en Angleterre. Mais le docteur Middleton, dans sa *Dissertation sur l'Origine de l'Imprimerie en Angleterre*, imprimée à Cambridge en 1735, in 4°, a prouvé démonstrativement que l'impression d'Oxford, de *l'Expositio S. Jeronimi in Simbolum Apostolorum*, est de l'an 1478, le compositeur ayant omis un X dans la date de la souscription (faute typographique dont nous avons plusieurs exemples dans les impressions du XV° siècle).' In a Bible at Augsburg, the last two figures in the date 1449 have been transposed, and should stand 1494. Other mistakes of a like nature are mentioned by Chevillier, Orlandi, Koelhoff, and Palmer; and amongst other similar blunders Dr. Middleton points out the following: 'Whilst I am now writing, an unexpected instance has fallen into my hands, to the support of my opinion; an *Inauguration Speech of the Woodwardian Professor, Mr. Mason*, just fresh from the press, with its date given ten years earlier than it should have been, by the omission of an X, viz. MDCCXXIV.; the very blunder exemplified in the last piece printed at Cambridge, which I suppose to have happened in the first from Oxford.'

Whether, however, Caxton was or was not the first English printer, it is quite certain that he was the first who made use of cast metal types, the works of Corsellis having been executed with merely wooden ones. During a long residence abroad, he had acquired a practical knowledge of the art; and on his return to England in 1471, set up a press in an old chapel of Westminster Abbey; and was for many years engaged in translating and printing books on a variety of subjects. His first work is, *Le Recueil des Histoires de Troyes* of Raoul le Fèvre, chaplain to the duchess of Burgundy; but *The Dicts and Sayinges of the Philosophers* is the earliest book known to have issued from his press with the date and place of printing; and we have no proof whatever that his six earlier works were printed in this country. Indeed it is stated in the life of Caxton, in Ames's *Typ. Antiquities*, p. xcv., that the French and English editions of the *Histories of Troy* are justly 'admitted to have been printed abroad.'

Caxton's types, as well as those of most of the early printers, were the Gothic, or black letter characters, mixed with a kind of secretary hand, and having the characteristics found in English MSS. of a period anterior to the Conquest. A facsimile of his types is here given from the dedication to the *Game and Playe of the Chesse*, showing the formation of his letters, and proving to our mind that, as compared with those of the Oxford printer Corsellis, they have an undoubted claim to greater antiquity.

To the right noble/right excellent & vertuous prince George duc of Clarence Erle of warwyk and of salisburye/grete chamberlayn of Englond & leutenant of Irelond oldest broder of kynge Edward by the grace of god kynge of England and of france /

It will be seen that Caxton's *d* at the end of a word is very singular, resembling the letters in the MSS. referred to; and that, instead of commas and periods, he used an oblique stroke thus /, still used in German books. Like other printers of his time, he never used any direction or catch words, and rarely numbered his leaves, and never his pages. He distinguished his books by a device, consisting of the initial letters of his name and a cypher for 74, the date of his introduction of the art into England.

Caxton is said to have printed 64 books; and was followed by his pupils or assistants, Theodore Rood, John Lettou, William Machilinia, and Wynkyn de Worde, all foreigners, and Thomas Hunt, an Englishman. All these pioneers of the art worthily maintained the honour of their master's name; and Wynkyn de Worde is especially remarkable for his improvements and typographical excellence, and as having been the first printer in England who introduced the Roman letter. He printed 410 works.

The spirit and taste of the patrons of the first printers are shown in the character of their earliest works, religious books and romances constituting the greater part of the productions of the father of English printing. But the art, although at first countenanced by the clergy, was soon looked upon with extreme jealousy by the hierarchy. Efforts were made towards the publication of the Bible; but for the first sixty or seventy years all copies of the Scriptures were printed in the Latin or some other language not understood by the generality of the people. A new era had, however, arrived. The doctrines of the Reformation had inspired the people with a strong desire to possess Bibles. Wickliffe's translation was never printed. The part of the Sacred Writings in the English language first produced by the printing press, was the New Testament, translated by William Tindal, assisted by Miles Coverdale, afterwards bishop of Exeter: it was printed at Antwerp, in 1526; but as it gave offence to Wolsey and the clergy, the whole impression was bought up and burnt. The first complete English Bible printed by authority, was Tindal's version, revised and compared

with the original by Coverdale, and afterwards examined by Cranmer, who wrote a preface for it. Of this edition, hence called 'Cranmer's Bible,' 500 copies were printed by Grafton and Whitchurch, to whom Henry VIII., in letters patent dated November 13, 1539, granted the sole right of printing the Bible for five years. It was ordered by royal proclamation to be set up in all churches throughout the kingdom, under a penalty of 40*s.* a month in every case of neglect. So great was the demand for copies of the Scriptures in the sixteenth century, that we have in existence 326 editions of the English Bible, or parts of the Bible, printed between 1526 and 1600.

The progress of the art in the first century of its existence was remarkable; but the earliest English printers did not attempt what the Continental ones were doing for the ancient classics. 'Down to 1540, no Greek book had appeared from an English press; Oxford had only printed a part of Cicero's epistles; Cambridge, no ancient writer whatever. Only three or four old Roman writers had been reprinted, at that period, throughout England. But a great deal was done for public instruction by the course which our early printers took; for, as one of them says: "Divers famous clerks and learned men translated and made many noble works into our English tongue, whereby there was much more plenty and abundance of English used than there was in times past." The English nobility were, probably, for more than the first half-century of English printing, the great encouragers of our press: they required translations and abridgements of the classics, versions of French and Italian romances, old chronicles, and helps to devout exercises. Caxton and his successors abundantly supplied these wants, and the impulse to most of their exertions was given by the growing demand for literary amusement on the part of the great. Caxton, speaking of his *Boke Eneydos*, says: "This present book is not for a rude uplandish man to labour therein, nor read it; but only for a clerk and a noble gentleman, that feeleth and understandeth in feats of arms, in love, and in noble chivalry." But a great change was working in Europe; the "rude uplandish man," if he gave promise of talent, was sent to school. The priests strove with the laity for the education of the people; and not only in Protestant but in Catholic countries schools and universities were everywhere founded. Here, again, was a new source of employment for the press—A, B, C's, or Absies, Primers, Catechisms, Grammars, Dictionaries, were multiplied in every direction. Books became, also, during this period, the tools of professional men. There were not many works of medicine, but a great many of law. The people, too, required instruction in the ordinances they were called upon to obey; and thus the statutes, mostly written in French, were translated and abridged by Rastell, our first law-printer.

'After all this rush of the press of England towards the diffusion of existing knowledge, it began to assist in the production of new works, but in very different directions. Much of the poetry of the sixteenth century, which our press spread around, will last for ever: its controversial divinity has, in great part, perished. Each, however, was a natural supply, arising out of the demand of the people; as much as the chronicles, and romances, and grammars were a natural supply; and as the almanacks, and mysteries, and ballads, which the people then had, were a natural supply. Taken altogether, the activity of the press of England, during the first period of our enquiry, was very remarkable. Ames and Herbert have recorded the names of 350 printers in England and Scotland, or of foreign printers engaged in producing books for England, that flourished between 1471 and 1600. The same authors have recorded the titles of nearly 10,000 distinct works printed amongst us during the same period. Many of these works, however, were only single sheets; but, on the other hand, there are, doubtless, many not here registered. Dividing the total number of books printed during these 130 years, we find that the average number of distinct works produced each year was 75.' (*Penny Magazine.*)

In the sixteenth century the broils consequent on the Reformation, although that event stimulated religious enquiry, did much to impede the progress of the art in England. But the civil wars and the gloomy religious spirit which succeeded to the pedantry and verbal criticism of the reign of James I., and which prevailed till the Restoration, interrupted still more the production of works calculated to cultivate the understanding. Indeed, we cannot but regard this period as the least favourable to the diffusion of knowledge of any period in the history of our literature. In the British Museum is a collection of controversial and quibbling tracts amounting to the enormous number of 30,000, while the impressions of new books printed during these stormy times were very few. Dr. Johnson has well remarked that the nation, from 1623 to 1664, was satisfied with two editions of Shakspeare's plays, which, probably, together did not amount to a thousand copies. But during this period we must not forget the present authorised version of the Bible, translated by the forty-seven distinguished scholars appointed by James I., and printed in 1611, which is allowed by competent judges to be one of singular merit, and indeed the most perfect ever produced. An unfavourable effect was also produced on our national literature, and on the progress of the press, by the licentiousness introduced by the literary parasites and courtesans of the Restoration. Under such a state of mental depression, Milton could obtain only 15*l.* for the MS. of his immortal *Paradise Lost*, and an Act of Parliament was actually in force enacting that only twenty printers should practise their art in the whole kingdom! Burton, who lived near this time, has drawn a miserable picture

of the abject condition of literary men when they had such patrons to rely upon: 'Rhetoric only serves them to curse their bad fortunes; and many of them, for want of means, are driven to hard shifts. From grasshoppers they turn humble-bees and wasps, plain parasites, and make the Muses mules, to satisfy their hunger-starved paunches and get a meal's meat.'

In addition to these impediments, the crown endeavoured, in the reign of Charles II., to destroy the activity of the press; 'and in this it had the example not only of all former reigns (in which nothing had been legally published without a license), but of the Long Parliament itself, which had laid severe restrictions upon the printing of "scandalous and unlicensed papers." At one time, indeed, it was ordered that no printing should be carried on anywhere but in the city of London, and the two universities; and all London printers were to enter into a bond of 300*l.* not to print anything against the government, or without the name of the author (or at least of the licenser) on the title-page, in addition to their own.' (Eccleston's *English Antiquities*, p. 325.) Speaking of the consequent scarcity of books in country places in the year 1685, Lord Macaulay (*History of England*) says:—

'Literature which could be carried by the post bag then formed the greater part of the intellectual nutriment ruminated by the country divines and country justices. The difficulty and expense of conveying large packets from place to place was so great, that an extensive work was longer in making its way from Paternoster Row to Devonshire or Lancashire than it now is in reaching Kentucky. How scantily a rural parsonage was then furnished, even with books the most necessary to a theologian, has already been remarked. The houses of the gentry were not more plentifully supplied. Few knights of the shire had libraries so good as may now perpetually be found in a servants' hall, or in the back parlour of a small shopkeeper. An esquire passed among his neighbours for a great scholar, if *Hudibras* and *Baker's Chronicle*, *Tarlton's Jests* and the *Seven Champions of Christendom*, lay in his hall window among the fishing rods and fowling pieces. No circulating library, no book society, then existed even in the capital; but in the capital those students who could not afford to purchase largely had a resource. The shops of the great booksellers, near Saint Paul's Churchyard, were crowded every day and all day long with readers; and a known customer was often permitted to carry a volume home. In the country there was no such accommodation; and every man was under the necessity of buying whatever he wished to read.' And he adds in a note that 'Cotton seems, from his *Angler*, to have found room for his whole library in his hall window; and Cotton was a man of letters. Even when Franklin first visited London in 1724, circulating libraries were unknown there. The crowd at the booksellers' shops in Little Britain is mentioned by Roger North in his life of his brother John.'

It has been ascertained by counting that the whole number of books printed during the fourteen years from 1666 to 1680, was 3,550, of which 947 were divinity, 420 law, and 153 physic, so that two-fifths of the whole were professional books; 397 were school-books, and 253 on subjects of geography and navigation, including maps. Taking the average of these fourteen years, the total number of works produced yearly was 253; but deducting the reprints, pamphlets, single sermons, and maps, we may fairly assume that the yearly average of new books was much under 100. Of the number of copies constituting an edition we have no record; we apprehend it must have been small, for the price of a book, so far as we can ascertain it, was considerable.

The period from the accession of George III. to the close of the eighteenth century is marked by the rapid increase of the demand for popular literature, rather than by any prominent features of originality in literary production. Periodical literature spread on every side; newspapers, magazines, reviews, were multiplied; and the old system of selling books by hawkers was extended to the rural districts and small provincial towns. Of those thus produced, the quality, with a few exceptions, was indifferent, and their cost was considerable. The principle, however, was then first developed, of extending the market, by coming into it at regular intervals with fractions of a book, so that the humblest customer might lay by each week in a savings-bank of knowledge. This was an important step, which has produced great effects, but which is even now capable of a much more universal application than it has ever yet received. Smollett's *History of England* was one of the most successful number-books; it sold to the extent of 20,000 copies.

We may exhibit the rapid growth of the publication of new books, by examining the catalogues of the latter part of the eighteenth century, passing over the earlier years of the reign of George III. In the *Modern Catalogue of Books*, from 1792 to the end of 1802, eleven years, we find that 4,096 new works were published, exclusive of reprints not altered in price, and also exclusive of pamphlets. Deducting one-fifth for reprints, we have an average of 372 new books per year. This is a prodigious stride beyond the average of 93 per year of the previous period. But we are not sure that our literature was in a more healthy condition. From some cause or other, the selling price of books had increased, in most cases 50 per cent., in others 100 per cent. The 2*s.* 6*d.* duodecimo had become 4*s.*; the 6*s.* octavo, 10*s.* 6*d.*; and the 12*s.* quarto, 1*l.* 1*s.* It would appear from this that the exclusive market was principally sought for new books; that the publishers of novelties did not rely

upon the increasing number of readers; and that the periodical works constituted the principal supply of the many. The aggregate increase of the commerce in books must, however, have become enormous, when compared with the previous fifty years; and the effect was highly beneficial to the literary character. The age of patronage was gone. (*Penny Magazine.*)

According to the last census, upwards of 30,000 persons are employed in printing, and 12,000 in bookbinding.

Printing in Scotland.—Printing was introduced into Scotland, and begun in Edinburgh, about thirty years after Caxton had brought it into England. Mr. Watson, in his *History of Printing*, says that the art was introduced into Scotland from the Low Countries by the priests who fled thither from the persecutions at home. Be this as it may, we find James IV. granting a patent in 1507 to Walter Chapman, a merchant of Edinburgh, and Andrew Mollar, a workman, to establish a press in that city. According to bibliographers, the most ancient specimen of printing in Scotland extant is a collection, entitled the *Porteus of Noblenes*, Edinburgh. In 1509, a *Breviary of the Church of Aberdeen* was printed at Edinburgh; and a second part in the following year. Very few works, however, appear to have issued from the Scottish press for the next thirty years; but from 1541, the date from which we find James V. granting licenses to print, the art has been pursued with success in the metropolis. At present, and from the beginning of the present century, it is perhaps the most distinguished craft in the city, being conducted in all its departments of typefounding, printing, publishing, and, we may add, paper-making at the mills in the vicinity.

Ireland.—Printing was not known in Ireland till about the year 1551, when a book in black letter was issued from a press in Dublin; but till the year 1700, very little printing was executed in that country, and until very recently Ireland had acquired little celebrity in this department of the arts, although possessing some respectable printing establishments.

America.—The art of printing has readily taken root and flourished among the civilised inhabitants of North America. The first printing press established in the American colonies was one set up at Cambridge, in Massachusetts, in the year 1638, the era of the foundation of Harvard College. It was established by the exertions and joint contributions of different individuals in Europe and America; and there is no doubt that the mechanism and types were imported from England. The first work which issued from this press was the *Freeman's Call*, and the second the *Almanac for New England*, both in 1639; the first book printed was the New England version of the Psalms, an octavo volume of 300 pages. In 1676, books began to be printed at Boston; in 1686, the art became known in Philadelphia; and in 1693, in New York. In the year 1700 there were only four printing presses in the colonies. Since that period, and especially since the revolution, which removed everything like a censorship of the press, the practice of the art has undergone enormous expansion. Among the occupations enumerated in the census of 1850 were 14,740 printers, and 3,414 bookbinders. In their style of typography and bookmaking, the Americans are still inferior to the English, sacrificing beauty and durability to economy and despatch. (*Chambers's Inform.*)

France.—The activity of the French press has very greatly increased since the time of the first Napoleon. Count Daru, in 1827 (*Notions Statistiques sur la Librairie*), estimated the number of printed sheets (exclusive of newspapers) produced by the French press in 1816, at 66,852,883; and it appears that in 1836 the number of printed sheets (exclusive of newspapers) had increased to 118,857,000; so that it may now be fairly estimated at from 130,000,000 to 140,000,000 sheets. The quality of many of the works which have issued from the French press is also very superior, such as the *Biographie Universelle*, the *Art de vérifier les Dates*, and Bayle's *Dictionary*; and it is doubted whether such books could have been published in any other country.

Germany.—The German printing press is always in a state of the greatest activity; the trade in books being very much facilitated by the book fairs of Leipsic, the Easter fair especially being frequented by all the booksellers of Germany, besides those of France, Switzerland, Denmark, Livonia, &c., in order to settle their mutual concerns and form new connections. In 1814 began a literary deluge, which still continues to increase. For the 5,000 works which then sufficed for the annual demand, we have now from 6,000 to 8,000. Private libraries are diminishing, and the public ones are daily increasing.

In Austria the printing press has made rapid strides of late years. The Imperial printing office in Vienna, under the able management of M. Auer, has become an establishment of the highest interest. At the Exhibition of 1851, he presented to the notice of the public a collection of the Lord's Prayer, printed with Roman type in 608 languages and dialects, the second section of which contained 206 languages and dialects, printed in the characters proper to the languages of their respective nations. He has collected together the following founts, many of which are, however, to be found in the British type foundries:—

Hieroglyphic.	Palmyric.
Hieratic.	Estrangelo.
Demotic.	Syriac.
Ethiopic and Amharic.	Cufic.
Himyaritic.	Arabic, Neschi.
Himyaritic (ornamented).	Mauritanic.
Cabylic, American inscript. Touaric and Thugga.	Phenician (ornamented).
	Punic.
Ancient Hebrew.	Numidian.
Samaritan.	Etrurian.
Hebrew.	Ancient Italian.
Raschi, or Rabbinic.	Runic.
German Hebrew.	Gothic.
German Raschi.	Celtic.
Hebrew, Spanish, Levantine.	Celtic (new shape).
Aramaic.	Anglo-Saxon.
Chaldee.	Ancient Greek.

Greek.
Coptic.
Cyrillic.
Cyrillic (differently shaped).
Russian, Servian, Wallachian.
Glagolitic.
Albanian.
Albanian (differently shaped).
Lycian.
Armenian.
Georgian.
Georgian (ecclesiast. letters).
Persepolitan cuneiform letters.
Pehlvi.
Zend.
Cabul.
Peguan.
Older Ind. signs.
Western Grotto inscription.
Asoka inscription.
Inscription of Guzerat.
Dynasty of Gupta (Allahabad).
Bengali.
Ahom.
Tibetan.
Passepa.
Kutila (ten years after Christ).
Devanagari (Sanscr. No. 1).
Devanagari (Sanscr. No. 2).
Kashmerian.
Sikh.
Assam inscript.
Mahratta.
Orissa.
Guzratee.
Kayti-Nagari.
Randscha.
Bandschin-Mola.
Multan.
Sindhee.
Nerbudda.
Kistna.
Telinga.
Karnata.
Tamul.
Malayalim.
Cingalese.
Maldivian.
Javanese.
Kiousa.
New Pali (No. 1.)
New Pali (No. 2).
Siamese.
Kambogo (with joint and without).
Laos.
Birmese.
Shyan.
Bugis.
Bisaya.
Batta.
Tagala.
Mongolese.
Mandschu.
Chinese.
Coreanic.
Formosan.
Japanese (Katakana No. 1).
Japanese (Katakana No. 2).
Japanese (Firokana).
Tschirokisian.

Russia.—The art was not introduced into Russia till the year 1560, when it was made known by a Russian merchant, who conveyed thither the materials of a printing office, with which many neat editions were printed. But as the Russians are a very superstitious nation and apt to raise scruples without any foundation, some of them, apprehending that printing might make some confusion or change in their religion, hired men to destroy the types and presses. No attempt was made to repair this injury or to discover the perpetrators of the fact. However, since that time they have admitted the press into Moscow and St. Petersburg, where until recently it made but slow progress.

Peculiarities of Early Printed Books.—The following are the points peculiar to the earliest productions of the first printers:—

Their forms were generally either large or small folio, or at least quarto: the lesser sizes were not in use.

The leaves were without running title, direction-word, number of pages, or divisions into paragraphs.

The character itself was a rude old Gothic mixed with secretary, designed on purpose to imitate the hand-writing of those times; the words were printed so close to one another, that it was difficult and tedious to be read, even by those who were used to manuscripts, and to this method; and often led the inattentive reader into mistakes.

Their orthography was various and often arbitrary, disregarding method.

They had very frequent abbreviations, which in time grew so numerous and difficult to be understood, that it became necessary to write a book to teach the mode of reading them.

Their periods were distinguished by no other points than the double or single one, that is, the colon and full-point; but a little after, they introduced an oblique stroke, thus, /, which answered the purpose of our comma.

They used no capital letters to begin a sentence, or for proper names of men or places. They left blank spaces for titles, and initial letters or other ornaments, in order to have them supplied by the illuminators, whose art, though in vogue before and at that time, did not long survive the improvements made by the printers in this branch of their art. [ILLUMINATION, ART OF.] These ornaments were exquisitely fine, and curiously variegated with the most beautiful colours, and even with gold and silver; the margins likewise were frequently charged with every variety of figures of saints, birds, beasts, monsters, flowers, &c., which had sometimes a relation to the contents of the page, though often none at all. These embellishments were costly; but for those who could not afford a great price, there were inferior ornaments, which could be done at a much cheaper rate.

The name of the printer, his place of residence, &c. &c., were either wholly omitted, or put at the end of the book, not without some pious ejaculation or doxology.

The date was likewise omitted or involved in some cramped circumstantial period, or else printed either at full length, or by numerical letters, and sometimes partly one way and partly the other; thus, One Thousand CCCC and lxxiiii. &c., but always at the end of the book.

There was no variety of characters, no intermixture of Roman and Italic, these being of later invention; but their pages were continued in a Gothic letter of the same size throughout.

They printed but few copies at once, for 200 or 300 was then esteemed a large impression; but upon encouragement from the learned, they increased their numbers in proportion.

Types.—Although most of the early printers were type-founders themselves, it does not appear in any prologue or colophon to the books printed by Caxton that he lays claim to the title of type-founder. It would appear that he obtained his type, which is precisely of the same character as that of John Brito of Bruges, from that city, or from the same founders who supplied or manufactured it for John Valdener of Utrecht. But as the art extended, the workmanship became inferior; so that while the productions of the first printers were executed in a very superior style, and the embellishments showed a great proficiency both in design and engraving, the productions of their competitors had all the crudeness and imperfection of a new invention; and in the seventeenth century the art sank into a very low state. At the commencement of the eighteenth century, Caslon made great improvements in casting types; as also Baskerville of Birmingham, in 1750, both in types and printing, which were subsequently carried to great perfection by Besley, Bulmer, Clowes, Corrall, Davison, McCreery, Spottiswoode, Whittingham, and a few others in London; by the Foulis, in Glasgow; by the Ballantynes, in Edinburgh; by Bodoni at Parma; by Didot in Paris; and by Brockhaus in Leipsic.

Practice of Printing.—Two classes of workmen are generally employed in printing: viz. *compositors*, who *set up* the types into lines and pages according to the MS. or *copy* furnished by the author; and *pressmen*, who apply ink to the surface of the *form* of types, and take off the impressions upon paper. The pressmen who work steam presses are called *machine minders*.

The following is the mode of proceeding adopted in most of the extensive establishments in London: The first thing done, when the sizes of page, type, and paper, are determined on, is to look over the MS., and see that it is correctly paged. It is then handed to a *clicker*, or foreman of a *companionship*, or certain number of compositors, each of whom has a *taking of copy*, or convenient portion of MS., given to him, to be set up in type.

Printers' types are of great variety in size, amounting to forty or fifty; the smallest is called *brilliant*, but is seldom used; *diamond* is a size larger, and *pearl* larger still, which latter type is used for printing the smallest Bibles and Prayer Books.

The larger sizes, used for printing bills posted in the streets, are usually called *double pica, two-line pica, two-line English, five-line pica, ten-line pica*, and so on. A complete assortment of printing types of one size is called a *fount*, and the fount may be regulated to any weight. Type-founders have a scale, or *bill*, as it is called, of the proportional quantity of each letter required for a fount, the letter *e* being more frequently used than other letters. A full account of printers' types is given under the heading Type.

Each compositor works at a kind of desk, called a *frame*, and generally has a frame to himself. The frames project laterally from the wall, with a left-hand light. Each frame is constructed to hold two pairs of cases, upper and lower, at the top. The types are arranged,

Upper.

A	B	C	D	E	F	G	A	B	C	D	E	F	G
H	I	K	L	M	N	O	H	I	K	L	M	N	O
P	Q	R	S	T	V	W	P	Q	R	S	T	V	W
X	Y	Z	Æ	Œ	J	U	X	Y	Z	Æ	Œ	J	U
ä	ë	ï	ö	ü			â	ê	î	ô	û	§	‡
1	2	3	4	5	6	7	à	è	ì	ò	ù	‖	†
8	9	0	£	ç	H.S.	k	á	é	í	ó	ú	¶	*

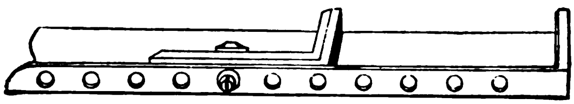
Lower.

&	[	æ	œ	'	j		*Thin Sp.*	(	?	!	;		fl
	b	c		d		e	i	s		f	g		ff
													fi
ffi	l	m		n		h	o	y	p	,	w	*en*	*em*
ffl													
z	v	u		t		*Spaces.*	a	r		q	:	*Quadr.*	
x										.	-		

each sort by itself, in little cells or *boxes*. The upper case, having ninety-eight boxes, all of equal size, contains the capital and small capital letters, figures, accents, and other types not used so frequently as the smaller letters; and in the lower case, which has fifty-four boxes of four different sizes, are disposed the small letters, together with the points, spaces, quadrats,

&c. The boxes in the cases are arranged in the best possible manner for facilitating the work of the compositor, and enabling him to pick up the types rapidly, the letters most frequently used being placed nearest to his hand; thus the point to which he brings the letters, after picking them out of their cells, is not far removed from the centre of the lower case; so that in a range of about six inches on every side he can obtain the c, d, e, i, s, m, n, h, o, p, u, t, a, and r. The *spaces* required for the division between every word lie close to his hand, at the bottom of the central division of the lower case. The cases, particularly the upper case, are placed in a sloping position, that the compositor may the more readily reach the upper boxes. The diagrams on p. 74 exhibit a pair of cases arranged according to the modern method.

The compositor stands opposite to his cases; and, having received directions respecting the size of the type, the width of the page, the author's wishes as to punctuation, capitals, italics, &c., places his copy before him, on a spare part of the upper case, and holds in his left hand a small instrument called a *composing stick*, usually made of iron, with a movable slide, capable, by means of a screw, of being adjusted to the different widths required in miscellaneous printing, as seen in the illustration. Having adjusted his stick to the proper width or *measure*, he lays in it a *setting rule*, or smooth piece of brass, the width of the measure, and the height of the type. With



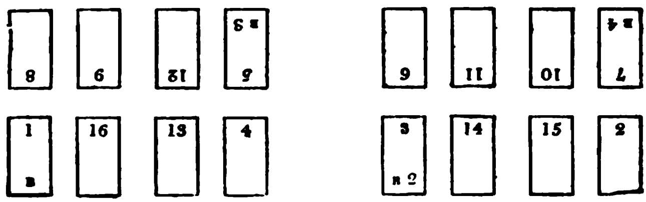
the right hand he now picks up the types, and arranges, or *sets*, them one by one in his composing stick. He does not look at the face of each, but only glances at the *nick* (see cut in art. TYPE), and takes for granted that if it come from the right box it must be the right letter. He secures each letter with the thumb of the left hand, as the types are placed side by side in line from left to right; and, when he comes to the end of his line, and finds that he has a syllable or word which will not fill out the measure, he has to perform a task which requires considerable care and taste. This is called *justification*. The first and last letters must be at the extremities of the line; and there must not be wide spaces between some words and crowding in others, but the distances between them must be made as nearly as possible uniform by changing the *spaces* (or short blank types, not so high as the letters, and therefore giving no impression), and thus *getting in* or *driving out* part or the whole of a word. The first line being thus justified, the compositor proceeds with the setting up of the next, and so on with a sufficient number of lines to fill his stick, and then, clasping the *stickful* by the rule and between the thumbs and first and second fingers of both hands, lifts the mass of types out of the stick, and places it upon a *galley*, or oblong tray of wood or metal, having an edge at the left side and top half an inch in height. This operation of filling and emptying the stick is repeated till the galley is sufficiently full, or the taking of copy is finished; when the *matter*, as it is then called, is taken away by the clicker, who divides it into the required lengths of pages, placing head-lines, signatures, &c., and binding them round tightly with cord. The clicker then *lays down* the pages in their proper positions on the *imposing stone*—a flat, smooth slab of stone, or, better, of iron—and they are fastened together in a *chase*. This operation is called *imposing*. The chase is a rectangular frame of different dimensions, according to the size of the paper to be printed, having two cross-pieces of the same metal, called a long and short cross, formerly mortised at each end, so as to be taken out occasionally, but now fixed. By the different situations of these crosses, the chase is fitted for different volumes: for quartos and octavos one traverses the middle lengthwise, the other broadwise, so as to intersect each other in the centre; for twelves and twenty-fours the short cross is placed nearer one end of the chase than the other; for folios, the short cross only is required, and for broadsides and small jobs no cross is wanted.

For fixing the pages in their places, the form is *dressed* thus: a set of *furniture*, consisting of slips of wood or metal, about half an inch in height, and of various thicknesses, is placed, some at the head, called *head-sticks*, some between the pages, called *gutters*, and others at the sides and feet, called *side* and *foot sticks*. The side and foot sticks are larger at one end than at the other, so that small wedges of wood, or *quoins*, may be driven tightly between them and the sides of the chase, locking up the types so firmly that the *form*, as the mass is then called, and which is represented in the cut (which by the way has no cross to the chase), may be carried from place to place with perfect safety. A form of eight pages of this Dictionary contains between 40,000 and 50,000 separate letters and spaces.

The sizes of books are reckoned by the number of leaves into which a sheet of paper is folded. Thus the largest size is *broadside*, or the whole size of the sheet; *folio*, or half the sheet; *quarto*, or a sheet folded into four leaves; *octavo*, or the sheet folded into eight leaves; *duodecimo*, or the sheet folded into twelve leaves; and so on. In imposing, the pages are of course laid down in positions the reverse of those which they will take when printed. The following diagrams show the mode of imposing sheets of 8vo and 12mo, the *outer form* being the outside, and the *inner form* the inside of the sheet.

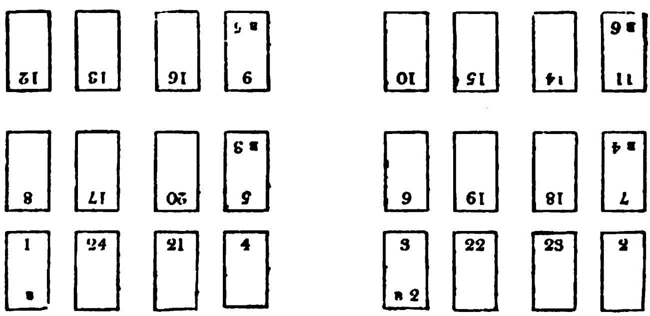
SHEET OF OCTAVO.

Outer Form. *Inner Form.*



SHEET OF TWELVES.

Outer Form. *Inner Form.*



It is necessary that the distances between the pages in each form should be placed with such exactness that the impression of the pages in one form shall fall exactly on the back of the pages of the other; thus making what is termed *register*.

As it is next to impossible but that mistakes should occur in *setting up* the types, the form is carried to a *proof press*, and an impression is taken, called the *first proof*. This proof, with the MS., is handed to the corrector of the press, or *reader*, and a *reading boy* reads the copy to him while he examines the proof and marks the necessary corrections and errors of the compositor. In correcting a proof sheet a set of symbols are used for the purpose of calling the attention of the compositor to the several kinds of errors, and to direct him how they are to be amended. These marks are best shown by the specimen of a corrected proof given under the head CORRECTING. When the corrector, or *reader*, has read his proof, it is handed to the compositor, who unlocks the form, and makes the corrections in the types, by lifting out the wrong letters by means of a sharp awl, or *bodkin*, and putting in right ones in their places. The form is then locked up again, taken to the press, and another proof is *pulled*. This is termed *the revise*, and is sent to the reader, with his first proof, that he may see that all the corrections have been properly made, put queries against doubtful matters for the author's consideration, and send it, thenceforth called a *clean proof*, with the MS., to the author. When the author returns his proof and revise, and is satisfied that the sheet is correct, the form, after having been finally read with care for press, is taken to the press or machine to have the requisite number of impressions struck off. Before this is done, however, care is taken that the matter at the beginning of the sheet connects with that at the end of the preceding, that the pages are correct, and that the *signatures* are in order.

The signatures are generally small capital

letters placed at the foot of the first page of each sheet, commencing with B, and omitting the J, V, and W. They are said to have been first used by John Koelhof, at Cologne, in 1472; but they exist in an edition of *Terence*, printed by Antonio Zorat, at Milan, in 1470. There is a Venetian edition of 'Baldi Lectura super Codic.' &c., printed by John de Colonia and Jo. Manthen de Gherretzem, in 1474, in which it is evident that these printers had only just become acquainted with the use of signatures, as these marks were not introduced till one-half of the work had been printed. The following tables show the signatures and folios of any given number of sheets, up to twenty-two in 8vo and 12mo, and up to eight in 18mo:—

Sheet of Octavo			Sheet of Twelves			Sheet of Eighteens		
No. of Sheets	Signature	Folio	No. of Sheets	Signature	Folio	No. of Sheets	Signature	Folio
1	B	1	1	B	1	1	B	1
2	C	17	2	C	25		C	13
3	D	33	3	D	49		D	25
4	E	49	4	E	73	2	E	37
5	F	65	5	F	97		F	49
6	G	81	6	G	121		G	61
7	H	97	7	H	145	3	H	73
8	I	113	8	I	169		I	85
9	K	129	9	K	193		K	97
10	L	145	10	L	217	4	L	109
11	M	161	11	M	241		M	121
12	N	177	12	N	265		N	133
13	O	193	13	O	289	5	O	145
14	P	209	14	P	313		P	157
15	Q	225	15	Q	337		Q	169
16	R	241	16	R	361	6	R	181
17	S	257	17	S	385		S	193
18	T	273	18	T	409		T	205
19	U	289	19	U	433	7	U	217
20	X	305	20	X	457		X	229
21	Y	321	21	Y	481		Y	241
22	Z	337	22	Z	505	8	Z	253

The paper used in printing is always damped before being sent to the press, wet paper taking the ink considerably better than dry. The warehouseman delivers the proper quantity of paper to the wetter, which is generally wetted thus: The quire of paper is opened, the fold at the back broken, and the paper divided into three, four, or five portions, or *dips*, drawn through a trough of clean water and laid on a board, dip after dip, till a convenient heap is made. This is put into a screw-press, a little pressure applied, and the next day the whole is *turned* and slightly pressed again, so that fresh surfaces of the paper coming into contact, the moisture is equally diffused throughout the heap. The paper used in printing is of three kinds: *imperfect paper*, consisting of 20 quires of 24 sheets, or 480 sheets to the ream; *perfect paper* (that most generally used) consisting of 21½ quires, or 516 sheets; and *news paper*, consisting of 20 quires of 25 sheets each to the ream, or 500 sheets. The *stamped sheets* of news paper (generally called *stamps*, and the plain paper *blanks*) are always received and delivered by the net number without allowing for spoilage in the press work; but in book work it is the practice to allow 16 sheets in each ream for *tympan sheet* and spoiled sheets. This number of sheets is, however, not all spoilt; the difference between the bad and the extra 16 sheets being delivered to the publisher as *overplus*. The table on the next page shows the quantity of perfect and imperfect paper required for one sheet of 16 pages of a work like this Dictionary, from 12 to 10,000 copies.

When the sheet is printed off by the pressman (as described below), the compositor lays up the forms, distributes the type, and proceeds, sheet after sheet, till the body of the work is finished; then the title, dedication, preface, introduction, contents, and any other matter left to the end is proceeded with, these being usually printed last. The distribution of the types, or putting back the letters into the several compartments of the case to which they belong, is performed with the greatest rapidity. The compositor wets the whole page or form, and takes up a number of lines on his composing rule. This wetting causes the types to adhere slightly together, and renders the

Quantity required of *Perfect* Paper			Quantity required of *Imperfect* Paper			For printing 1 Sheet of 16 Pages	Total Number of Copies the Paper will make
reams	quires	sheets	reams	quires	sheets		
0	0	15	0	0	15	12 copies	15
0	1	4	0	1	4	25 „	28
0	2	6	0	2	6	50 „	54
0	3	7	0	3	7	75 „	79
0	4	8	0	4	8	100 „	104
0	5	9	0	5	9	125 „	129
0	6	12	0	6	12	150 „	156
0	7	13	0	7	13	175 „	181
0	8	14	0	8	14	200 „	206
0	10	18	0	10	18	250 „	258
0	12	22	0	12	22	300 „	310
0	15	0	0	15	0	350 „	360
0	16	3	0	16	3	375 „	387
0	17	4	0	17	4	400 „	412
0	19	6	0	19	6	450 „	462
1	0	0	1	1	12	500 „	516
1	4	6	1	5	18	600 „	618
1	8	14	1	10	2	700 „	722
1	10	18	1	12	6	750 „	774
1	13	0	1	14	10	800 „	826
1	17	4	1	18	17	900 „	928
2	0	0	2	3	0	1,000 „	1,032
2	10	18	2	13	18	1,250 „	1,290
3	0	0	3	4	12	1,500 „	1,548
3	18	18	3	15	6	1,750 „	1,806
4	0	0	4	6	0	2,000 „	2,064
6	0	0	6	9	0	3,000 „	3,096
8	0	0	8	12	0	4,000 „	4,128
10	0	0	10	15	0	5,000 „	5,160
12	0	0	12	18	0	6,000 „	6,192
14	0	0	15	1	0	7,000 „	7,224
16	0	0	17	4	0	8,000 „	8,256
18	0	0	19	7	0	9,000 „	9,288
20	0	0	21	10	0	10,000 „	10,320

manipulation easy. He then takes up a few words between his right-hand finger and thumb, and by a dexterous motion throws off the several letters into their various boxes. Distribution is performed about four times faster than composition.

Presswork.—The pressman's business is to *work off* the forms thus prepared and corrected by the compositor; in doing which there are four things required: paper (prepared as above described), ink or colouring matter, balls or rollers, and a press or machine. [Paper; Printing Ink; Press; Printing Balls or Rollers; Printing Machine.]

In working at a hand press, the pressman first lays the *inner form* on the press, and prints one copy, which is called a *press revise*; this he takes to the person appointed to revise it, and while that is being done proceeds to secure the form on the table of the press by means of quoins; to place his *tympan* sheet; to fix the *points*, which make small holes in the paper, enabling him to cause the pages to fall precisely on the back of each other when the second side of the paper is printed, and to produce an even and uniform impression in all the pages. He then cuts his *frisket*, which preserves the margin of the paper clean, and, when the revise is corrected, proceeds to ink the surface of the types by means of balls or (most frequently) rollers. When the whole impression of one side of the paper is printed, he lifts the form off the press, washes the ink off the face of the type with lye, and rinses it with water. He then proceeds in a similar manner with the *outer form*, which completes the sheet. This process is continued sheet after sheet till the work is complete, care being taken that the work is printed of the proper colour, and that that colour should be uniform throughout the book.

Warehouse Work.—When the sheets have been printed on both sides, the warehouseman takes them away, and hangs them up on poles to dry, varying the number of sheets hung up together from five or six to ten or eleven, according to the heat of the room, or the pressure of business. When dry the sheets are taken down from the poles, carefully *knocked up*, and put away in the warehouse in piles. The sheets are then *cold-pressed*. The pressure is applied by means of hydraulic

pumps, of from two to five hundred tons pressure. They consist simply of double-acting force-pumps, with rams or cylinders of small bore, but with a great force from an engine to act upon the pistons. This forces the water through a very strong pipe beneath the floor to other large cylinders, fitted also with pistons, under the presses. Of course, whatever force is applied to the small pistons in the pumps, an equal amount of pressure is produced on every square inch of the large pistons in the cylinders under the presses, and thus a prodigious pressure on the sheets of paper is the result.

Above the upper part of one of these large cylinders are square iron plates, which form a base on which to rest the piles of sheets of paper to be pressed. These plates, like those of similar function in the printing-press, are very thick and are stiffened beneath by iron braces. Each press may be connected with the pump, or disconnected from it at pleasure, so that one may be giving up or receiving a supply of sheets while the others are full and in action.

Each sheet, before it is put into the press, is placed between two sheets of thin smooth millboard. The process of *filling in* the sheets between the millboards is performed at very wide tables. It requires two boys at each table to do each work. One takes out from between two sheets of pasteboard the sheet of paper that has been pressed, and the other, almost at the same instant, puts another in, shifting the several sheets, both of paper and pasteboard, from pile to pile, in the course of the manipulation, with dexterity and rapidity. As fast as a sufficient number of the rearranged sheets are ready, a boy takes them away, and places them in the press, while another boy continually brings a fresh supply of those that have been pressed to take their places. The pressing which the sheets receive in this operation makes an astonishing difference in the smoothness and beauty of the paper when the book comes to be bound.

When the book is nearly finished, from ten to fourteen consecutive sheets are laid upon the gathering board in order, and collected sheet by sheet by boys, who deposit each *gathering* in a heap at the end of the table, so constructed that when a boy has deposited his gathering he has only to turn himself and begin again. These gatherings are then carefully *collated*, to ascertain that the different sheets are correct and in order, and folded up the middle. When the work is finished the gatherings are put together, or *in books*, one of each forming a copy of the work, and pressed. The work is now completed, and awaits the order of the bookseller, &c., for delivering the copies into the hands of the bookbinder.

Printing in Colours.—In many of the early printed books, the initial letters, and occasionally other parts, were printed in red. This was done by two workings at press, and was an imitation of the earlier fashion of illuminating MSS. This is the case with the Mentz Bible by Fust and Gutenberg. The first printers soon began to print these large ornamented letters, the letter itself being in some instances red and the ornamental part blue, in others the letter is blue and the ornamental part red. These letters were afterwards finished by hand, as is apparent in the *Psalter* of 1457, printed by Fust and Schœffer, who also showed great ingenuity and skill in the large letter B in the same book, which is printed with red ink, and the ornamental part, consisting of a flourished line, as if it had been drawn with a pen, extending from the top to the bottom of the folio page, with blue ink. Of two copies which we have examined, one was in the library of George III. at Buckingham Palace, and the other is in the possession of Earl Spencer.

The first edition of the *Speculum Humanæ Salvationis*, which was printed at Haarlem, about the year 1440, by Laurence Coster, has engravings on wood printed in a different coloured ink from the body of the work. A copy of this rare and curious work, which Mr. Savage examined some years ago, in the valuable collection of Messrs. Longman, impressed him momentarily with the idea that the engravings were pen-and-ink drawings, and that the ink had turned brown with age, so precisely was this effect produced by the tone of the ink.

We mention these early specimens of printing with coloured inks, and in the case of the *Psalter* having two blocks of wood with two different colours, as being produced by means of the press, coeval with the generally received date of the invention of printing, to show the impossibility of the case. For, looking at the freedom of the engraving in the letter B, and the skill of the workman in printing it, it must be evident to every person conversant with the art that this perfection could only be obtained by long practice; and the contrast between these productions of the first practitioners and their competitors, when the art became public, puts the question beyond a doubt, as an examination of the facsimiles given by Heinecken from *Fables* printed at Bamberg about 1461, from the *Legendes* printed at the same place about 1470, and also the *Fables of Æsop* by Caxton, will, we think, satisfy the most scrupulous and sceptical.

Towards the end of the fifteenth century the art was extended to the imitation of pen-and-ink sketches with a coloured ground, by the great masters of painting; and in a few years it was further extended to the imitation of drawings in chiaroscuro, and that with such success as to induce some of the first artists to encourage it by drawing the subjects on the blocks. The first practisers of this extension of the art were, Michael Wohlgemuth of Nuremberg, who furnished the designs for the *Nuremberg Chronicle*, and also engraved them on wood, and Mair, a native of Landshut, the disciple of Martin Schön; between whom the priority rests of printing in chiaroscuro. After them were Girolamo Mocetto, Lucas Cranach, Baldassar Peruzzi, Hans Burghmair, and Ugo di Carpi (who has been generally

regarded as the inventor of this style of printing, but dates prove this opinion to be erroneous), Domenico Beccafumi, John Ulric, Albert Altdorfer, Hans Baldung, Lucas van Leyden: all these were born in the fifteenth century. In the sixteenth century, there were Antonio da Trenta, Giovanni Nicolo Vicentino (called Rossigliani), Herbert Goltz or Goltzius, Andrew Andreani, Henry Goltz or Goltzius, Abraham Bloemaert, Paul Moreelze, Bartolomeo Coriolano, Giovanni Battista Coriolano, Christopher Jegher, George l'Allemand, and Frederick Bloemaert. In the seventeenth century, there were Louis Businck, Vincent le Sueur, Antonio Maria Zanetti, Nicholas le Sueur, Comte de Caylus, Edward Kirkhall, and John Baptist Michael Papillon. This last-mentioned engraver, in his treatise on *Engraving on Wood*, expressly states that Albert Durer engraved some subjects in chiaroscuro, and that he had examined them in the collection of the king of France; Parmigiano also superintended the printing in this manner of a number of his own designs; Titian, Raffaelle, and other eminent masters made designs on the blocks for printing; and the author of *An Enquiry into the Origin of Printing in Europe* states, that 'one of the greatest princes and connoisseurs of our age used to say, he saw nothing in prints that could give him the pleasure he received from looking at the wood prints done in chiaro-oscuro by Hugo di Carpi.' This prince was the duke of Orleans, regent of France.

After these were John Baptist Jackson, who executed a number of subjects, of a large size, in chiaroscuro, copied from celebrated paintings in churches in Italy, and from private collections; he afterwards established a manufactory at Chelsea for printing paper-hangings in oil colours, a speculation, however, which was unsuccessful. Some of his productions printed in colours were complete failures, the oil having spread in the paper; and the subjects being in the first instance engraved with strong lines, they have the appearance of coarse engravings coloured by children. Jackson flourished from 1720 to 1754. Mr. John Skippe, an amateur, executed many subjects in chiaroscuro very adroitly.

Gubitz, an engraver at Berlin, has produced a great number of subjects printed in colours, of a very superior character, but none of them can be called imitations of drawings. Mr. Savage was the first who attempted to imitate drawings in water colours by means of the common printing press, and accomplished the applying of all the colours used by artists to the composition of printing ink, thus serving as a pioneer to more skilful persons who might devote themselves to this branch of art; and he succeeded in producing fac-similes of the drawings of different artists so as to deceive everyone who examined them. Messrs. Whiting and Branston, of Beaufort House, applied printing in coloured inks to the prevention of forgery, and to embossing on paper; and Messrs. Vizetelly and Branston have produced some very tasteful things in colours; but neither of these establishments, to our knowledge, turned their attention to the imitation of drawings. Mr. Baxter subsequently executed beautiful specimens in a manner that would have been deemed totally impossible in the early state of the art.

The practice of printing parts of books in red ink is still followed in some prayer-books and almanacs, the saints' days and holidays being *red-letter days*. Some years ago a curious book was written and published on printing in colours by Mr. Savage. Still more recently, printing in gold and other metals has been practised. This is done by printing with a sort of size, and afterwards applying the metal leaf. But the copies of some of the works of the great painters, considered as specimens of printing in colours, are really beautiful as works of art. The copy picture is made in colours, and the blocks for printing each colour and shade are cut in relief on *surface-metal*, consisting of perfectly smooth plates of type metal. These plates are then printed by the ordinary method, great care, however, being taken that each colour falls in its right place.

Several ingenious contrivances have been invented for working in various colours, such as Dolby's, Loft and Stafford's, Carpenter's machines, &c. It will be sufficient to describe the last, as given in Wood's *Typographical Advertiser*:—

'The invention patented some time ago by Mr. C. Knight, is a process whereby fac-similes of designs in four colours are produced on the same sheet, before it leaves the press, by means of a *revolving carriage* or bed upon which the blocks are secured. The process, invented a few years ago, for printing in four colours by means of *turning the tympan* with the sheet secured on it, was somewhat less complicated than Mr. Knight's. These methods, however, necessitate the application of the four coloured inks at every revolution and impression; and also involve considerable outlay for machinery. W. Carpenter's process, on the contrary, gives rise to no expenditure whatever; and, in its manipulation, everything is carried on in as straightforward a manner as ordinary black printing. It may be thus briefly described: A form, for example, is set-up by the compositor; he then divides it into four sections, and so imposes them, in one chase, that the same relative corner of each (whichever may be chosen) shall point towards the middle of the chase. It is then ready for the pressman. It requires making-ready, with points placed, according to the tact of the workman, in such position as may be deemed expedient; four points being sufficient in all, and these so placed that the sheet may be pointed when turned either to the right or to the left hand. Should a thousand copies be required, the two hundred and fifty sheets are printed in the first colour. They are then simply turned round, in either direction, and again printed with the second colour. They are then again turned round,

and printed with the third colour, and again for the fourth. And now we have a thousand perfected impressions, consisting of four varieties—that is, with the four colours differently arranged: two hundred and fifty of each kind. Should the whole possible number of combinations of four colours—namely, twenty-four—be required, nothing more is necessary than, while the sheets are being worked in the second colour, to turn a portion of their number into the third and fourth positions—which produces three kinds of sheets, or twelve single varieties—and, while working the third colour, take half of each of the three kinds, and work them respectively in the second, third, and fourth positions—producing six kinds of sheets, or twenty-four single varieties. It will be readily seen that, in the production of four varieties only, a different arrangement of them will be produced according to the direction in which the sheets are turned, and likewise the order in which the several colours are employed. It will also be seen, by practical men, that the blocks and the tympan retaining their relative positions throughout, the inner-lays are not interfered with, as they would be if a revolution took place in either case. Moreover, one inking apparatus is sufficient; and each colour has time to set before another is worked over it—which may sometimes be required.'

The following is the mode of printing cuts with two or more *rainbow tints* at the same time: Take the cut, which is to be printed in black, ink it well and rather full, and get a perfect impression on paper not very damp; then lay the face of the printed paper carefully on the surface of the block prepared for engraving the whites on the tinted ground, and give it a good soft pull. This will transfer to the tint block a fac-simile of the wood engraving itself. The tint-block is then handed over to the engraver, who cuts out the whites for the high lights, &c., according to his taste, and with a view to effect. The tint-block is printed first, and the pressman must be careful in distributing his different inks to make them fade away and blend at the given points. This is an easy matter after a little practice. The black block is then worked over the tint in the usual way.

Composing and Distributing Machines.—The desire to expedite the process of composing and distributing has led to the invention of some ingenious machines for those purposes. One, the work of M. Sörensen, of Copenhagen, was exhibited at Paris in 1855, and was described by Mr. Charles Knight in his report. Three others, the inventions of Mr. Young, of Fleet Street, London, and of Mr. Alden and Mr. Mitchell, both of New York, were shown at the Great Exhibition in London in 1862. We can only afford room for a short account of the latter, as described by the inventor himself. Two of each of his composing and distributing machines have been for some years at work in the establishment where this Dictionary is printed. The *compositor* (says Mr. Mitchell) is in shape a right-angled triangle, placed horizontally, with a key-board at one of the sides, furnished with thirty-nine keys. Each key, when pressed, strikes out a type, from one of an equal number of brass slides standing at an incline upon the machine in a row nearly parallel to the key-board. The type thus liberated is conveyed upon a band, moving in a direction at right angles with the key-board, to another band (forming the hypothenuse of the triangle), which carries it on to its destination. Arrived here, it is placed on end and pushed forward, to make room for the next type, by means of a notched or serrated wheel called the *setting wheel.* The words are thus put together with great rapidity, in a long line of about thirty inches, which is afterwards divided by the compositor into lines of the required length. The principle of the machine consists in the combination of bands of lengths and velocities of revolution so varied as to enable the types at different distances from the wheel to reach it in the order in which the keys are struck. The *compositor* is capable of setting up types at the rate of six letters per second, or 21,600 per hour; but as the human fingers cannot attain to such rapidity, and allowance must be made for the operations of *justifying* and *correcting*, the work of an average trained operator will probably not exceed 24,000 or 25,000 ens per day, which is about equal to the work of two men setting up type in the ordinary mode. As each machine can employ two operators, the daily production is about 50,000 ens.

The *distributor* is a small machine of circular form. The lines of type to be distributed are placed successively in a long channel, in which they are pressed forward towards a vibrating metal *finger*. By this finger each type is separated from the line, pushed aside, and dropped on to a grooved brass wheel revolving horizontally. In the grooves of this wheel pins are placed, on which the types are hung by means of nicks, the ends of the types projecting below the under surface of the wheel at distances varying according to the position of the nicks. As each letter arrives over its receptacle, it is lifted off its pin, and dropped into its place, being pushed a little forward to make way for the next arrival. When the line is filled in this way, it is removed by the boy to the *compositor*.

The distributor is self-acting, and requires only the attention of a boy. It distributes 8,000 letters per hour.

Printing for Special Purposes.—The art-printing called NATURE PRINTING is described under its own heading. But a newer art-process, based upon the same principle, or rather *direct* nature-engraving, has been invented by Mr. George Wallis. By this method, called by the inventor *autotypography*, drawings are so executed that they can be afterwards impressed or engraved in soft metal plates by an analogous process (although differing in details) to that employed in impressing natural objects. The drawings are executed on paper, sheet gelatine, and even on the plate-glass bed of the special machine. When on the former, a tint

is also impressed in the plate, which can be afterwards treated as a mezzotinto for the high lights, &c. The majority of the specimens exhibited by the inventor are from drawings executed on gelatine, with a suitable drawing material, which constitutes an important element in the invention. The most delicate touches, both of pen and brush, are transferred to the plate from this medium, which being transparent affords every facility for the accurate tracing of the design or writing; and as the subject is reversed in the process of impressing or engraving, an almost instantaneous operation, which takes up only two or three seconds, no reversal of the drawing or writing is required as in the case of ordinary engraving. The plates are printed from at an ordinary copper-plate press in the usual manner, and when the surface is hardened by a coating of steel or nickel, will yield a considerable number of impressions. The chief aim and merit of the invention is, that the original expression, spirit, and touch of the artist who executes the drawing are preserved and transmitted to the plate. The drawings are stated to be as easy of production, within certain well-defined limits, as those of ordinary pen and washed drawings. The cost of printing is of course that of ordinary plate printing; but as several plates can be engraved from the same drawing, the delay of printing from only one plate can be avoided without the cost of electrotyping.

By the process of *electro-block printing*, drawings, engravings, letterpress, or music, can be reproduced either greatly extended or reduced in size. To effect this on an enlarged scale, the surface of a sheet of vulcanised Indian rubber, equal in size to the subject, is coated with a thin film of an elastic composition, and on it is taken an impression of the print, block, or plate. This is done without difficulty, and without injury to the print from which it is taken. By means of an ingeniously contrived frame with a double-screw action, the Indian rubber is stretched equally on all sides to the size required. While retained in this form, it is laid down on a lithographic stone or zinc plate, properly prepared; and it is then in a condition to furnish impressions in the ordinary method. The reduction of objects is obtained by stretching the Indian rubber sheet of the size required till it can cover the subject; the impression being then taken, it is released from the strain and returns to its original size, and the process is continued as above described. For surface printing, some further operations are required. The impression of the desired size having been received on zinc plate or stone, the surface of either is exposed to the action of an acid which will eat away the parts of the surface unprotected by the ink, leaving the impression in relief. From this a matrix is taken, and an electrotype or a stereotype cast can be produced, fitted for any of the ordinary modes of type-printing.

Another contrivance for printing is that of M. Auguste Leouillet, of Paris. His *numéroteurs mécaniques* are made for numbering coupons, ailway certificates, and bank-notes, for paging account books, or for any other purpose for which a continuous series of numbers is required. It may be adapted either for use in the hand, or for printing in a press. The hand instrument consists of a rowel-formed circle, on the points of which are cut in steel the ten numerals. It turns on an axle which may hold from two to six or more of these rowels. The figure or figures that are to move are left free; those that are stationary are fixed by a screw at the side to prevent their being disturbed by the action of the others. The figure is changed by the action of a small lever that rises up by the wooden handle, the pressure of which turns the rowel so as to bring the next figure in its place, and at the same time inks itself from a small inking apparatus fixed above the figures. Thus, with six rowels, numbers 1 to 999,999 may be impressed, the first of the series appearing 000,001. This instrument may also be used dry for stamping anything where colour is not needed, but only an impression; or with common marking-ink for stamping bales or goods of wooden packing-cases. For printing, eight rowels with ten axils each may be used fixed in a form, or rather on a plate, furnished with spaces to admit the movable types. If we suppose that they number, as at first prepared, from 1 to 80, a horizontal handle moves all the necessary figures, and the next impression would give from 81 to 160. This process may be combined with the printing of labels requiring dates, such as those of the month and year. In such cases the necessary fixed type is prepared in the usual manner, and space is left for the numéroteurs to be inserted, which are then operated on in the manner already described.

Messrs. Waterlow and Sons exhibited at the Great Exhibition of 1862 a *railway ticket printing machine*, worked by steam, but which can easily be adapted to hand working. In it the fixed type is placed in a frame, and the movable figures or letters are engraved in steel on a brass rowel. By a vibrating action the frame is brought under a press to convey the impression to the paper, and the reversed movement brings the next type in succession to its place. It is self-inking.

Harrild's *newspaper addressing machine* consists of a sliding groove of some length, on which is placed a *galley* containing as many of the required directions as it will hold set up in type, and locked up. A treddle moves it along under a sort of parchment frisket or tympan, till a direction arrives just under the space cut in the frisket, the newspaper envelope is laid over the frisket, and the treddle brings down a pressure on it. The galley continues sliding on till all the directions have been impressed, when it is removed to make room for another.

Bank-note Printing.—The old method of printing bank-notes was from copper, and subsequently from steel, plates. But in the year

1853, Mr. Alfred Smee, surgeon to the Bank of England, suggested to the directors that the time had arrived for the adoption of *surface* printing instead of *plate* printing, in the preparation of the notes, as admitting of greater rapidity and more complete identity of appearance. Although objecting to any additional change in the form or device of the note, the directors consented to the prosecution of a series of elaborate experiments. In these experiments Mr. Smee was assisted by Mr. Hensman, engineer to the Bank, and by Mr. Coe, superintendent of the note-printing machines. Engravers, press-makers, paper-makers, and ink-makers, all contributed their opinions or inventions towards the preparation of bank-notes by surface printing. At length, in 1854, all the difficulties were surmounted: on January 1, 1855, the first bank-note appeared under the new system. The bank-note differs very little from its predecessor; the Britannia is, perhaps, somewhat more artistic; but the letters, figures, and flourishes are scarcely altered. Indeed, it was a fixed policy on the part of the directors to render any change in the appearance of their bank-notes as little perceptible as possible. The great novelty was in the preparation of the plate for surface-printing. Until the year 1837, the device was engraved on the plate itself from which the impressions were to be printed; from 1837 to 1854, the engraving was managed on the siderographic process; but on the new system, introduced in 1855, the design for the note is made up and engraved on several small pieces of copper, brass, and steel, according to the quality and minuteness of the engraving; the lines of the device being raised instead of sunken. From the model thus made a metallic mould is obtained, by electro-deposition. Mr. Smee's platinised silver voltaic batteries are employed as the source of power. These batteries had already been advantageously used in multiplying the copper-plates for the Ordnance maps. The model is left in the precipitating trough containing sulphate of copper solution until a layer of copper has been deposited upon it thick enough to bear handling; the device of course appears on this film in intaglio, not in relief, and serves as the mould from which copies of the original model are to be made. Being separated from the original model, and again immersed in the solution, this mould receives a deposit, which, when thick enough, is separated from the mould giving the device. It is this, in relief instead of intaglio, when backed up and strengthened by solder or other metal, which forms the plate from which Bank of England notes are printed. There are about seventy or eighty kinds of Bank of England notes, differing either in their denominations (5*l.*, 10*l.*, &c.), or in the town where they are issued (London, Manchester, Birmingham, &c.); each of these has required its own original model; but any one model would suffice for an almost endless number of notes—seeing that one model will yield an indefinite number of moulds, and one mould an indefinite number of plates. By the electro-metallurgic process, nearly ten million bank-notes are printed annually without any necessary renewal of the original models. The paper, supplied by the same establishment in Hampshire which has furnished bank-note paper for a long series of years, is manufactured in a manner which exhibits almost as many novelties as the preparation of the plates. Until the year 1855, the *water-mark* (one of the safeguards against forgery) was produced by forming a device with fine wire in the mould or frame employed in making the paper. Now, however, the device for the water-mark is engraved on steel-faced dies, and transferred by stamping to brass plates; by a delicate process these brass plates are adjusted to or within the paper-making mould. There is a gradation of light and shade in the present water-mark, very difficult to imitate. The sheets of paper, before they leave the Hampshire mill, undergo a process of dry-glazing by rolling. It has been necessary to make a change in the ink as well as in the paper, in adapting the arrangements for surface printing. The bank-note ink, instead of being prepared from the husks of Rhenish grapes, is now made by a combination of a peculiar varnish with the soot resulting from burning coal-tar naphtha in closed chambers. The printing presses, and the mode of printing, differ materially under the present surface-printing system, as compared with the old plate printing; the mechanism comprises many beautiful novelties.

Excellent as are now the Bank of England notes, there are not wanting experienced men who contend that a more elaborate device, practicable only by the plate-printing method, would be better. Forgery has diminished, but it has not quite died out. The Bank directors opposed any marked change in the simplicity of the device on these grounds: That forgers can imitate elaborate engraving sufficiently well to deceive the public, if not bank-clerks; that parti-coloured notes, invented by Sir William Congreve, were successfully imitated; that the general public, not being judges of artistic effect, and having little discrimination for the different styles of different artists, are apt to be easily deceived by the same *general* appearance in a forged note with which they have been familiar in a real note, and take imperfect imitations of it quite as readily; and that on the whole, long familiarity with one form of inscription and one style of ornament is the best preventive against forgery. These opinions were contested by the late Mr. Henry Bradbury, in a lecture delivered at the Royal Institution, on May 9, 1856; the lecture was afterwards printed as a quarto pamphlet, with engravings of three specimen bank-notes from designs by Mr. John Leighton. Mr. Bradbury contends that the object to be aimed at should be to impart to each bank-note an individuality, thereby expressing qualities which are not within the province of mechanical imitation. This is to be done by employing a design of a

high artistic character; seeing that the work which has the genius of an artist imprinted on it, is not to be imitated by an inferior mind. The vignette is the part of a note on which the most artistic skill is displayed; and Mr. Bradbury urges that this skill should be still further exercised. Early in the present century the Plymouth Dock Bank, to lessen the forgery of its notes, caused a vignette to be engraved; the forgeries at once ceased. When a really skilful artist can engrave a vignette of a high character, his social position and prospects are such as to take him out of the influence and temptation of forgers. The higher the class of the engraving, the less the likelihood of forgery; seeing that the work of every real artist has an individuality about it which others could not imitate. Admitting that the Bank of England note exhibits simplicity of design, Mr. Bradbury remarks, 'The objection I have to submit is that its simplicity is *too* simple—not having upon the face of it those features which characterise the true art-point. The vignette is a specimen the reverse of what I have been advocating; it is alike deficient in conception and execution. Surface-printing having been chosen as the medium, the Bank authorities were restricted in the application of their art. In consequence of this, the Bank of England note in its present form is unworthy of the bank and the nation.' Assuming that high art should be employed to give character to the simplest parts of the note, Mr. Bradbury would employ machine-engraving—such as medallion work, and guilloche or rose-engine work—to produce ornamental details of any desired degree of complexity; straight lines, waved lines, circles, ellipses, &c., may be combined in ways almost illimitable. To produce these results—the combination of high art and simplicity with mechanical intricacy, as a double check to the forger—Mr. Bradbury believes that plate-printing would be necessary. Mr. Grubb, engineer to the Bank of Ireland, has expressed opinions very similar to those of Mr. Bradbury. (Knight's *English Cyclopædia*.)

Laws affecting the Press.—These laws are 39 Geo. III. c. 79, amended by 51 Geo. III. c. 65, and 2 & 3 Vict. c. 12. There is no censorship over the press, which is, however, amenable to the remedy of an injured party, or to the correction of criminal justice. (Wharton's *Law Lex.* 2nd ed. 1860.)

Glossary of terms used in printing, most of them not explained in the body of this work:—

Ascending Letters. Capital letters and the following small ones: b, d, f, h, k, l. The *descending letters* are the g, j, p, q, y.

Astronomical Characters. The signs for the twelve zodiacal constellations, for the planets and dragon's head and tail, for the aspects, and for the moon in her various changes.

Author's Proof. The proof sheet or slips of a work corrected by the author himself.

Back Boxes. The compartments of the compositor's upper case not required for the ordinary types, but used for irregular sorts.

Bad Copy. Badly written or troublesome MS.

Batter. When the faces of types become injured in a form.

Beard of a Letter. The outer angle of the square shoulder of the shank of a type.

Benvenue Money. Money paid by a new hand to his fellow workmen, who spend it in beer. The term is evidently a corruption of *bien venu*, or welcome.

Bill. A weight of a fount of types, in certain fixed proportions. [TYPE.]

Blank Pages. Pages which do not print, made up of quadrats and furniture.

Bodkin. A sharp-pointed piece of steel wire, used for drawing letters out of a form in correcting. [CORRECTING.]

Body of a Work. The subject-matter of a book, without the title-page, preface, contents, introduction, and index.

Book. A complete copy of a work, the gatherings being put together ready for the bookbinder. This operation is called *booking*. The press used for pressing the books just before binding is called the *book press*.

Book House. A printing office in which book work is its chief employment. A *News House* is confined to newspaper printing.

Bottom Notes or *Foot Notes.* The notes at the foot of a page.

Brace. A character made to various lengths and bodies, thus ⏞.

Brass Rules. Pieces of brass of various fractional parts of a pica in thickness, type high, for printing lines.

Bringing up or *Making ready* a form of type. The operation of overlaying or underlaying, cutting out, &c. for equalising the impression, or bringing out the light and dark parts of woodcuts.

Cassie Paper. The two outer quires of a ream of paper.

Casting up. A calculation of the number of thousands of types contained in a sheet of a work, made for the purpose of ascertaining the value of the compositor's work.

Clean Proof. A sheet composed with very few errors, or a proof pulled after correction for the author.

Clicker. The compositor who has the management of a companionship, or number of men engaged in setting up one or more works.

Close Spacing. When thin and middling instead of thick spaces are used between words by the compositor. It is objectionable, as is also *open spacing*.

Cock-up Letter. A large letter, standing above the line, formerly used for the first word of a book.

Collate. To examine the signatures of a book, to see that it is complete and ready for the bookbinder.

Companionship. See *Clicker*.

Corrector. The old name for the reader, or person employed to detect the errors made by the compositor in setting up the types.

Dele. In correcting a proof, the mark thus ₰, expunging a letter or word.

Devil. In old times boys employed to take the printed sheets off the tympan of the press. They were commonly bedaubed with ink. *Taking-off* boys at machines are now called *flies* or *fly boys*.

Double. In composing, a word or words set up twice.

Drive out. To space widely, and also if copy makes more matter than was reckoned upon. The reverse is called *to get in*.

Even Lines. When work, such as newspaper composition, is in great haste, paragraphs are divided into a few lines to each man, and he is required to begin and end a line, often with very close or wide spacing.

Fat. With compositors, short or blank pages and widely leaded matter; and with the pressmen, small numbers paid as much as if 250 copies were worked off.

Fat-face. Thick-face types, giving very black impressions.

Fine Presswork. [PRINTING.]

Fire-eaters. Rapid compositors.

First Proof. The first impression pulled from the type after composition.

Fly Boys. See *Devil*.

Foot Notes. See *Bottom Notes.*

Fore Edge. The outer edge of a sheet when folded to the proper size of a book.

Foreign. All composition in foreign languages.

Fractions. Types cast in one piece representing $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$. *Half-fractions* are cast to one-half the body of a type, and make all kinds of combinations.

Fragments or *Oddments.* The few pages at the end of a book which do not make a sheet, and the title, preface, contents, &c., imposed so as to print off economically.

Frame. The kind of desk on which a compositor rests his cases.

French Rules. Dashes mostly of brass, thus: ——◆——.

Friar. A pale patch in a printed sheet where the form has not taken the ink as in the other parts. Black patches are called *monks.*

Frisket. An iron frame, covered with paper, and cut out to the sizes of the pages when being printed off, so as to keep the margin of the paper clean.

Full-face Letter. Types in which the ascending letters occupy the whole of the body, and the descending letters hang over, and are kerned.

Geometrical Characters. Types used for the *plus, minus,* &c.

Get in. See *Drive out.*

Good Copy. Well-written MS. or printed copy.

Gutter. The space between the pages forming the back margin of a book.

Horse. A charge made for work not done, a practice to be discouraged for obvious reasons. Also an apparatus, of a desk-like form, used by the pressman on which to lay his white paper.

Imperfect Paper. A ream containing only 480 sheets; *perfect paper* containing 516 sheets.

Imperfection. A sheet required by the bookbinder to make a volume complete. Types not cast up to the proper quantity are also so called.

Inner Form of a sheet. The form which begins with the second page, usually worked off first.

Letter. Type.

Literals. Errors made by compositors in single letters only.

Lye. A solution of alkali, used for cleaning the ink off the forms of type.

Macule. A faulty impression, appearing somewhat doubled in the printing off.

Make up. To put matter into pages.

Making ready. See *Bringing up.*

Margin. The white paper round the printed portion of a sheet.

Matter. Types set up.

Metal. Type metal, used also for stereotype plates.

Monk. See *Friar.*

Nick. The mark in a type by which the compositor sees which side to put into his stick in setting up. [TYPE.]

Oddments. See *Fragments.*

Oriental. Eastern languages.

Out. Matter omitted by the compositor in setting up.

Outer Form. The form beginning with the first page of the sheet, and worked off last.

Outside Quires. See *Cassie Paper.*

Overlays. Pieces of paper pasted on a sheet put between the tympans, for the purpose of obtaining a regular and flat impression.

Overrun. To carry over parts of lines or pages.

Overseer. The manager of a printing office.

Pamphlet. A work consisting of more than one sheet, but not more than five sheets.

Perfect Paper. See *Imperfect Paper.*

Periodicals. Works published at stated intervals, but neither newspapers nor those which are proposed to be finished in a certain number of parts.

Picker. A man who corrects stereotype plates.

Picks. Dirt in a form, or metal flaws in stereotype plates.

Pie. Broken matter.

Plane down. To flatten the face of the form of type.

Platen. That part of the press which comes down upon the form, producing the impression.

Point Holes. Holes made in working off a sheet of white paper, so that when the outer form is worked the pages shall fall in register.

Pull. To take an impression.

Reader. See *Corrector.*

Register, to make. To arrange the pages of both sides of a sheet so that they shall fall precisely upon one another.

Reiteration. The outer form, or second form worked off; called also, by abbreviation, the *ret.*

Revise. A proof pulled after the corrections have been made by the compositor.

Set off. The ink from one recently printed sheet coming off upon and spoiling another.

Slur. An impression smeared at press.

Specimen Page. A page pulled neatly on good paper to show the proposed size and type.

Stet. [CORRECTING.]

Taking. A portion of copy given to a compositor at one time.

Token. Ten quires of paper.

Two-line Letters. The large types sometimes used at the beginning of a book or chapter, and occupying two or more lines in depth.

Tympan. The parchment frame on which the sheet to be printed is laid at press.

Underlays. Pieces of paper pasted under pages or woodcuts to bring them up to the required height.

White line. A line of quadrats producing a blank the depth of a line of print.

Printing Balls or Rollers. The balls by which the ink was formerly applied to the forms in presswork [PRINTING] were made of a sort of wooden funnel with handles, the cavities of which were filled with wool or hair, and a piece of felt or leather nailed over the cavity, and made extremely soft by soaking in urine and being well rubbed. One of these the pressman took in each hand, and, applying them to the ink-table, daubed and knocked them together, to distribute the ink equally, and then blacked the form, by beating with balls upon the face of the letter. A considerable improvement upon this plan has been effected by means of rollers, invented by Mr. B. Foster, and now and for some years past in general use. These rollers consist of a combination of treacle and glue, which runs on the ball stock, a cylinder of wood covering an iron rod, affixed to which are two handles. Instead of beating, as in the case of balls, the cylinder is rolled over the face of the form, and the ink thereby applied in a much more even manner, and with a considerable decrease of labour. Experience, however, teaches us that the ball is the best means of inking fine wood engravings and producing the most brilliant impressions.

The best method of keeping a roller in good condition is to smother it in common ink when out of use, hanging it up in a cool place in warm weather, and in a warm place in cool weather, but never in a draught or current of air.

Printing Ink. The black ink used in printing books is prepared from certain quantities of linseed oil, black resin, soap, and lampblack. An excellent black ink has been made by Mr. Savage, who gives the following

opinions as to the requisites of black printing ink for fine work: 'Intenseness of colour, impalpability, covering the surface of the type or engraving perfectly, quitting the surface of the type or engraving when the paper is pressed upon it and adhering to the paper, not smearing after it is printed, and retaining its appearance without any change. The linseed oil is boiled, and after the smoke begins to rise from the boiling liquid, a bit of burning paper stuck in the cleft end of a long stick should be applied to the surface, to set it on fire, as soon as the vapour will burn; and the flame should be allowed to continue (the pot being meanwhile removed from over the fire, or the fire taken from under the pot), till a sample of the varnish, cooled upon a pallet-knife, draws out into strings of about half an inch long between the fingers. To six quarts of linseed oil thus treated, six pounds of resin should be gradually added, as soon as the froth of the ebullition has subsided. Whenever the resin is dissolved, one pound and three-quarters of dry brown soap, of the best quality, cut into slices, is to be introduced cautiously, for its water of combination causes a violent intumescence. Both the resin and soap should be well stirred with a spatula. The pot is to be now set upon the fire again, in order to complete the combination of all the constituents. Put next of well-ground indigo and Prussian blue, each 2½ ounces, into an earthen pan, sufficiently large to hold all the ink, along with 4 pounds of the best mineral lampblack, and 3½ pounds of good vegetable lampblack; then add the warm varnish by slow degrees, carefully stirring, to produce a perfect incorporation of all the ingredients. This mixture is next to be subjected to a mill, or slab and muller, till it be levigated into a smooth uniform paste.'

The following is Mr. Savage's recipe for making one pound of superfine printing ink: Balsam of capivi, 9 ounces; lampblack, 3 ounces; indigo and Prussian blue together, p. seq. 1¼ ounce; Indian red, ¾ ounce; turpentine (yellow) soap, dry, 3 ounces. This mixture is to be ground upon a slab, with a muller, to an impalpable smoothness. The pigments used for colouring printing inks are, carmine, lakes, vermilion, red lead, Indian red, Venetian red, chrome yellow, chrome red or orange, burnt terra di Sienna, gall-stone, Roman ochre, yellow ochre, verdigris, blues and yellows mixed for greens, indigo, Prussian blue, Antwerp blue, umber, sepia, &c.

In consequence of the late immense rise in the prices of the materials for making ink, experiments are said to have been made on petroleum, gas refuse, &c., and the ink thus produced has been mixed with the genuine. These filthy compositions spoil the books in which they are used, exhibiting a disagreeable-looking halo round the print, and imparting a most unpleasant odour to the volume when opened.

Printing Machine. The earliest printing presses were the common wooden screw press, for the first essential modification of which the world is indebted to the late Earl Stanhope [PRESS.] In Dr. Dibdin's *Bibliographical Decameron* may be seen cuts of the earliest printing presses.

Prior to the introduction of printing machines presswork was one of great labour whenever extraordinary expedition was required. It was particularly the case with newspapers, of which, with the utmost exertion, scarcely more than 750 copies per hour could be obtained; the consequence was that in newspaper offices where the circulation was extensive, it was found necessary, in order to get the paper published in time, to compose two or more sets of types, and work them off simultaneously at as many presses. An enormous increase in the composition and presswork was the result.

In describing the various machines, it will be observed that in the diagrams illustrating their leading principles or arrangements—

The black parts represent the inking apparatus.

The diagonal lines represent the paper cylinders which give the impression.

The perpendicular lines represent the types or plates.

The arrows represent the track of the sheet of paper.

In the year 1790 Mr. W. Nicholson, the editor of the *Philosophical Journal*, took out a patent for certain improvements in printing; and, on reading his specification, everyone must be struck with the extent of his ideas on the subject. To him belongs, beyond doubt, the honour of the first *suggestion* of printing by means of cylinders; the following are his own words, divested of legal redundancies:—

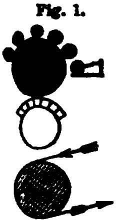
'In the first place, I not only avail myself of the usual meth ds of making type, but I likewise make and arrange them in a new way, viz. by rendering the tail of the letter gradually smaller. Such letter may be imposed on a cylindrical surface; the disposition of types, plates, and blocks, upon a cylinder, are parts of my invention.

'In the second place, I apply the ink upon the surface of the types, plates, &c. by causing the surface of a cylinder smeared with colouring matter to roll over or successively apply itself to the surface of the types, &c., or else I cause the types to apply themselves to the cylinder. It is absolutely necessary that the colouring matter be evenly distributed over this cylinder, and for this purpose I apply two, three, or more smaller cylinders, called distributing rollers, longitudinally against the colouring cylinders, so that they may be turned by the motion of the latter; if this colouring matter be very thin, I apply an even blunt edge of metal or wood against the cylinder.

'In the third place, I perform all my impressions by the action of a cylinder, or cylindrical surface, i. e. I cause the paper to pass between two cylinders, one of which has the form of types attached to it, and forming part of its surface, and the other is faced with cloth, and serves to press the paper so as to take off an impression of the colour pre-

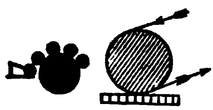
viously applied; or otherwise, I cause the form of types, previously coloured, to pass in close and successive contact with the paper wrapped round a cylinder with woollen cloth.' He also described a method of raising the paper cylinder to prevent the type from soiling the cloth.

Fig. 1.



Nicholson's arrangement for arched type.

Fig. 2.



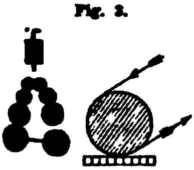
Nicholson's arrangement for common type.

This specification describes the principal parts of modern printing machines; and had Mr. Nicholson paid to any one part of his invention that attention which he fruitlessly bestowed on attempts to fix types on a cylinder, or had he known how to curve stereotype plates, he would, in all probability, have been the first *maker* of a printing machine, instead of merely suggesting the principles on which they might be constructed.

The first working printing machine was the invention of Mr. T. Kœnig, a native of Saxony; he submitted his plans to Mr. T. Bensley, the celebrated printer, and to Mr. R. Taylor, the scientific editor of the *Philosophical Magazine*. These gentlemen liberally encouraged his exertions, and in 1811 he took out a patent for improvements in the common press, which, however, produced no favourable result. He then turned his attention to the use of a cylinder, in order to obtain the impression, and two machines were erected for printing the *Times* newspaper, the readers of which were told, on the 28th of November, 1814, that they held in their hands a newspaper printed by machinery, and by the power of steam.

In these machines the type was made to pass under the cylinder, on which was wrapped the sheet of paper, the paper being firmly held to the cylinder by means of tapes. The ink was placed in a cylindrical box, from which it was forced by a powerful screw, depressing a tightly fitted piston; thence it fell between two iron rollers. Below these were placed a number of other rollers, two of which had, in addition to their rotatory motion, an end motion, i. e. a motion in the direction of their length. The whole system of rollers terminated in two, which applied the ink to the types. In order to obtain a great number of impressions from the same form, a paper cylinder (i. e. a cylinder in which the paper is wrapped) was placed on each side of the inking apparatus, the form passing under both. The machine produced 1,100 impressions per hour; subsequent improvements raised them to 1,800 per hour.

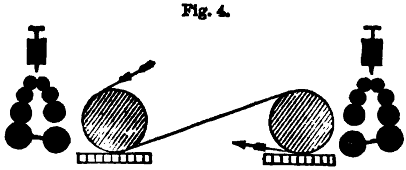
Fig. 3.



Kœnig's single, for one side of the sheet.

The next step was the invention of a machine (also by Mr. Kœnig) for printing both sides of the sheet: it resembled two single machines, placed with their cylinders towards each other, at a distance of two or three feet. The sheet was conveyed from one paper cylinder to the other by means of tapes; the track of the sheet exactly resembled the letter S, if laid horizontally, thus, ∞. In the course of this track the sheet was turned over. At the first paper cylinder it received the impression from the first form, and at the second paper cylinder it received the impression from the second form; the machine printed 750 sheets, on both sides, per hour. This machine was erected for Mr. T. Bensley, and was the only one made by Mr. Kœnig for printing on both sides of the sheet: this was in 1815.

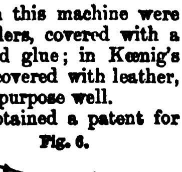
Fig. 4.



Kœnig's double, for both sides of the sheet.

About this time Messrs. Donkin and Bacon were also contriving a printing machine, having in 1813 obtained a patent for a machine in which the types were placed upon a revolving prism. The ink was applied by a roller, which rose and fell with the irregularities of the prism; and the sheet was wrapped on another prism, so formed as to meet the irregularities of the type prism. One of these machines was erected for the university of Cambridge, and was a beautiful specimen of ingenuity and workmanship; it was, however, too complicated, and the inking was defective, which prevented its success. Nevertheless, a great point was attained; for in this machine were first introduced inking-rollers, covered with a composition of treacle and glue; in Kœnig's machine the rollers were covered with leather, which never answered the purpose well.

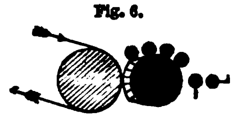
Fig. 5.



Donkin and Bacon's machine for type.

In 1815 Mr. Cowper obtained a patent for curving stereotype plates for the purpose of fixing them on a cylinder. Several of these machines, capable of printing 1,000 sheets per hour on both sides, are at work at the present day;

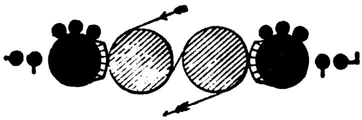
Fig. 6.



Cowper's single, for curved stereotype.

and twelve machines on this principle were made for the Bank of England a short time previous to the issue of gold.

Fig. 7.



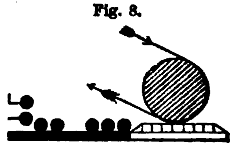
Cowper's double, for both sides of the sheet.

It is worthy of note that the same object seems to have occupied the attention of Nicholson, Donkin and Bacon, and Mr. Cowper, viz. the revolution of the form of types. Nicholson sought to do this by a new kind of type, shaped like the stones of an arch. Donkin and Bacon sought to do this by fixing types on a revolving prism; and at last it was completely effected by the curving of a stereotype plate by Mr. Cowper.

In these machines two paper cylinders are placed side by side, and against each of them is placed a cylinder for holding the plates. Each of these four cylinders is about two feet diameter; on the surface of the plate cylinder are placed four or five inking-rollers, about three inches diameter; they are kept in their position by a frame at each end of the plate cylinder, the spindles of the rollers lying in the notches on the frame, thus allowing perfect freedom of motion, and requiring no adjustment. The frame which supports the inking-rollers, called the *waving-frame*, is attached by hinges to the general frame of the machine; and the edge of the plate cylinder is indented, and rubs against the waving-frame, causing it to wave or vibrate to and fro, and, consequently, to carry the inking-rollers with it, thus giving them a motion in the direction of their length, called the *end motion*. These rollers distribute the ink upon three-fourths of the surface of the plate cylinder, the other quarter being occupied by the curved stereotype plates. The ink is held in a trough; it stands parallel to the plate cylinder, and is formed by a metal roller revolving against the edge of a plate of iron. In its revolution this roller becomes covered with a thin film of ink, which is conveyed to the plate cylinder by an inking-roller vibrating between both. On the plate cylinder the ink becomes distributed, as before described, and as the plates pass under the inking-rollers they become charged with colour. As the cylinders continue to revolve, the plates come in contact with a sheet of paper in the first paper cylinder, whence it is carried, by means of tapes, to the second paper cylinder, where it receives an impression on its opposite side from the plates on the second plate cylinder, and thus the sheet is perfected. These machines are applicable only to stereotype plates, but they formed the foundation of the future success of Applegath and Cowper's printing machinery, by showing the best method of furnishing, distributing, and applying the ink.

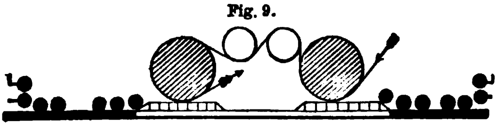
In order to apply this method to a machine capable of printing from type, it was only necessary to do the same thing in an extended flat surface or table, which had been done on an extended cylindrical surface. Accordingly Mr. Cowper constructed a machine for printing both sides of the sheet from type, securing by patent the inking apparatus, and the mode of conveying the sheet from one paper cylinder to the other by means of drums and tapes.

Fig. 8.



Applegath and Cowper's single machine.

Fig. 9.



Applegath and Cowper's double machine.

Mr. A. Applegath, who was a joint proprietor with Mr. Cowper in these patents, obtained patents for several improvements. Mr. Cowper had given the end motion to the distributing rollers by moving the frame to and fro in which they were placed. Mr. Applegath suggested the placing of these rollers in a diagonal position across the table, thereby producing their end motion in a simpler manner.

The diagonal rollers have an admirable tendency to spread out the ink in a smooth stratum, by the sliding of the table in a different direction to the lines of revolution; but there must be considerable friction at their axes by the constant tendency of the table to thrust the rollers sideways or endways, which must be provided against, or they will soon wear untrue. He also contrived a method of applying two feeders to the same printing cylinder; these latter inventions are more adapted to newspaper than to book printing. Numerous machines have been constructed upon the joint inventions of Messrs. Applegath and Cowper, which are modified in a great number of ways for the various purposes of printing books, bank-notes, newspapers, &c.; they have, in fact, superseded Mr. Kœnig's machines in the office of Mr. Bensley (who was the principal proprietor of Kœnig's patent), and also in the office of the *Times*, as was announced in that journal. No less than forty wheels were removed from Kœnig's machines when Mr. Bensley adopted the improvements of Messrs. Cowper and Applegath.

Having, on the first trial of their machines, discovered the superiority of the inking roller and table over the common balls, they immediately applied them to the common press, and with complete success. The invention, however, was immediately infringed throughout the kingdom, and copied in France, Germany, and America; and it would have been as fruitless to attempt to stop the infringement of the patent as it was found in the case of the kaleidoscope. This invention has raised the quality of printing generally.

Improvements in printing machines were effected by Mr. Wayte and by Mr. David Napier; but the immense and increasing demand of the *Times* upon their powers, rendered it necessary to provide a machine which would *work off from* 12,000 *to* 15,000 *copies per hour*. This demand was supplied by the invention of the late Mr. Applegath, who gave the author the following description, first published by the late Dr. Lardner: He decided on abandoning the reciprocating motion of the type form, arranging the apparatus so as to render the motion continuous. This necessarily involved circular motion, and accordingly he resolved upon attaching the columns of type to the sides of a large drum or cylinder, placed with its axis vertical, instead of the horizontal frame which had been hitherto used. A large central drum is erected, capable of being turned round its axis. Upon the sides of this drum are placed vertically the columns of type. These columns, strictly speaking, form the sides of a polygon, the centre of which coincides with the axis of the drum, but the breadth of the columns is so small compared with the diameter of the drum, that their surfaces depart very little from the regular cylindrical form. On another part of this drum is fixed the inking table. The circumference of this drum in the *Times* printing machine measures 200 inches, and it is consequently 64 inches in diameter. This drum is surrounded by eight cylinders, also placed with their axes vertical, upon which the paper is carried by tapes in the usual manner. Each of these cylinders is connected with the drum by toothed wheels, in such a manner that their surfaces respectively must necessarily move at exactly the same velocity as the surface of the drum. And if we imagine the drum thus in contact with these eight cylinders to be put in motion, and to make a complete revolution, the type form will be pressed successively against each of the eight cylinders, and if the type were previously inked and each of the eight cylinders supplied with paper, eight sheets of paper would be printed in one revolution of the drum.

It remains, therefore, to explain, first, how the type is eight times inked in each revolution; and secondly, how each of the eight cylinders is supplied with paper to receive their impression. Beside the eight paper cylinders are placed eight sets of inking rollers; near these are placed two ductor rollers. These ductor rollers receive a coating of ink from reservoirs placed above them. As the inking table attached to the revolving drum passes each of these ductor rollers, it receives from them a coating of ink. It next encounters the inking rollers, to which it delivers this coating. The types next, by the continued revolution of the drum, encounter these inking rollers, and receive from them a coating of ink, after which they meet the paper cylinders, upon which they are impressed, and the printing is completed.

Thus in a single revolution of the great central drum the inking table receives a supply eight times successively from the ductor rollers, and delivers over that supply eight times successively to the inking rollers, which, in their turn, deliver it eight times successively to the faces of the type, from which it is conveyed finally to the eight sheets of paper held upon the eight cylinders by the tapes.

Let us now explain how the eight cylinders are supplied with paper. Over each of them is erected a sloping desk, upon which a stock of unprinted paper is deposited. Beside this desk stands the *layer on*, who pushes forward the paper, sheet by sheet, towards the fingers of the machine.

These fingers, seizing upon it, first draw it down in a vertical direction between tapes in the eight vertical frames until its vertical edges correspond with the position of the form of type on the printing cylinder. Arrived at this position, its vertical motion is stopped by a self-acting apparatus provided in the machine, and it begins to move horizontally, and is thus carried towards the printing cylinder by the tapes. As it passes round this cylinder it is impressed upon the type, and printed. It is then carried back horizontally by similar tapes on the other side of the frame, until it arrives at another desk, where the *taker off* awaits it. The fingers of the machine are there disengaged from it, and the *taker off* receives it, and disposes it upon the desk. This movement goes on without interruption; the moment that one sheet descends from the hands of the *layer on*, and being carried vertically downwards begins to move horizontally, space is left for another, which he immediately supplies, and in this manner he delivers to the machine at the average rate of two sheets every five seconds; and the same delivery taking place at each of the eight cylinders, 16 sheets are delivered and printed every five seconds. It is found that by this machine in ordinary work *between* 10,000 *and* 11,000 *per hour can be printed*; but with very expert men to deliver the sheets, a still greater speed can be attained. Indeed, the velocity is limited, not by any conditions affecting the machine, but by the power of the men to deliver the sheets to it.

In case of any misdelivery a sheet is spoiled, and, consequently, the effective performance of the machine is impaired. If, however, a still greater speed of printing were required, a machine of the same kind, without changing its principle, would be sufficient for the exigency;

but it would be necessary that the types should be surrounded with a greater number of printing cylinders.

It may be right to remark, that these surrounding cylinders and rollers, in the case of the *Times* machine, are not uniformly distributed round the great central drum; they are so arranged as to leave on one side of that drum an open space equal to the width of the type form. This is necessary in order to give access to the type form so as to adjust it.

One of the practical difficulties which Mr. Applegath had to encounter in the solution of the problem, which he has so successfully effected, arose from the shock produced to the machinery by reversing the motion of the horizontal frame, which in the old machine carried the type form and inking table, a moving mass which weighed one ton! This frame had a motion of 88 inches in each direction, and it was found that such a weight could not be driven through such a space with safety at a greater rate than about 45 strokes per minute, which limited its maximum producing power to 5,000 sheets per hour.

Another difficulty in the construction of this vast piece of machinery was so to regulate the self-acting mechanism that the impression of the type form should always be made in the centre of the page, and so that the space upon the paper occupied by the printed matter on one side may coincide exactly with that occupied by the printed matter on the other side. The type form fixed on the central drum moves at the rate of 70 inches per second, and the paper is moved in contact with it of course at exactly the same rate. Now, if by any error in the delivery or motion of a sheet of paper it arrive at the printing cylinder 1-70th part of a second too soon or too late, the relative position of the columns will vary by 1-70th part of 70 inches—that is to say, by one inch. In that case the edge of the printed matter on one side would be an inch nearer to the edge of the paper than on the other side. This is an incident which rarely happens, but, when it does, a sheet is, of course, spoiled. The waste, however, from that cause is considerably less in the present vertical machine than in the former less powerful horizontal one.

The vertical position of the inking rollers is more conducive to the goodness of the work—for the type and engraving are only touched on their extreme surface—than the horizontal machine, where the inking rollers act by gravity; while any dust shaken out of the paper, which formerly was deposited upon the inking rollers, now falls upon the floor. With this machine 50,000 impressions have been taken without stopping to brush the form or table.

The principle of this vertical cylinder machine is capable of almost unlimited extension.

Notwithstanding the great powers of production of Mr. Applegath's machine, the still-increasing requirements of the *Times*, with the repeal of the paper duty and the consequent demands of the cheap newspapers, made it necessary that something more should be done. An American machine, the invention of Messrs. Hoe and Co. of New York, has been recently introduced into this country, and several have been constructed by Mr. Whitworth of Manchester for the *Times* and other newspapers. By means of these machines, combined with a recently discovered process of stereotyping and multiplying type-high forms, there is practically no limit to the number of copies of a newspaper which can be produced within a given time.

The printing presses of Messrs. Hoe and Co. had, like Applegath's vertical machines, been invented previous to 1851, and cannot therefore be regarded as novelties; but at that date only one had been introduced into Europe, and no sample or even model was exhibited in Hyde Park. There was a small model of the ten-cylinder press in the Exhibition of 1862, but nothing else to illustrate the mechanism by which the principal newspapers of the metropolis and great provincial towns are printed. The first presses sent by Messrs. Hoe and Co. to this country were for *Lloyd's Weekly Newspaper*, and were of the six-cylinder size. These were followed by two ten-cylinder machines ordered by Mr. Walter for the *Times*, with the condition that they were to be made by an English machinist who should be approved by him. The *Star* and the *Manchester Examiner* also ordered Hoe presses of English make, and the example thus set was speedily followed by the *Manchester Guardian*, the *Daily Telegraph*, the *Scotsman*, the *Illustrated London News*, and in fact all the leading papers in the United Kingdom. The experience, however, of the English-made machines, had meanwhile (probably from the novelty of the manufacture) not been quite so satisfactory as that of those produced by Messrs. Hoe and Co., and this gave a decided preference to the New York machines. Mr. Walter still continues to use two of Applegath's eight-cylinder vertical machines in printing the *Times* and *Evening Mail*, but only as subsidiaries, the chief burden of the work falling on the two ten-cylinder Hoes made by Mr. Whitworth, and these are now said to perform admirably. They are driven at the rate of thirty-two revolutions per minute, which gives a printing rate of 19,200 per hour, or about 16,000 including stoppages. Much of the ingenuity exercised both in the Applegath and Hoe machines was directed to the chase, which had to hold securely upon its curved face the mass of movable type required to form a page. The complicated contrivances by which this was effected have now been entirely superseded by the use of stereotype plates; but before proceeding to describe the process by which these are obtained, it may be well to draw attention to some of the points which seem to have determined the preference now given to the Hoe presses over the Applegath. The course of the sheet in *laying on* at the Hoe machine is as direct as it can be made, short of printing from a continuous web,

and the taking off is performed with great regularity by means of a wooden frame, which rises and falls with each impression of the printing cylinders. At the Applegath press the direction of the sheet has to be changed from a perpendicular to a lateral motion to correspond with the vertical position of the main drum. A taker off is also required for each impression cylinder as well as a layer on, thus considerably increasing the number of hands. The American machine also possesses a decided superiority in the arrangements for securing good register, though the ingenious finger motion by which this result is obtained becomes objectionably rapid in the largest size of presses. For the mode of producing the plates for the *Times* and other newspapers, see STEREOTYPING.

The Spottiswoode Press.—The first successful application of steam, as a motive power, to printing presses with a *platen* and vertical pressure, was made in the establishment where this Dictionary is printed. Convinced of the superiority of the impression made by flat as compared with that of cylindrical pressure, the late Mr. Andrew Spottiswoode (a name to be remembered amongst the most eminent in his profession), assisted by his chief engineer, Mr. Brown, succeeded, after many experiments, in perfecting a machine which combines the excellence of work of the hand press with four times its speed, and with a uniformity of colour which can never be attained by inking by hand. The main point of the invention is the endless screw or drum which takes the carriage and type from each end under the platen, and after the impression is taken by means of a crank returns it to its original position. The frisket is attached to the tympan at the bottom near the tympan joints, so that when the tympan is lifted from the form by the machinery, the tympan and frisket open at the upper end, contrary to the usual way in presses worked by manual labour, and the printed sheet is left on the tympan resting on the frisket. These presses are called *double platens*; but they ought, in honour of their inventor, to be named Spottiswoode presses.

Printing, Nature. [NATURE PRINTING.]

Prior. [ABBOT.]

Prioress. The superior of certain convents of nuns.

Prisage (Fr. prise, *a taking*). An ancient right of the crown, by which the king or his butler was empowered to take two tuns of wine from every ship importing twenty tuns or more into England. It is mentioned in the earliest pipe rolls as a source of royal revenue. By a charter of Edward I. it was commuted to a tax of two shillings on every tun of wine imported by merchant strangers. The commutation, on the presumption that thirty to forty tuns were the average lading of a ship carrying Bordeaux or Gascony wine, is pretty nearly equivalent to the ordinary price of wine at the latter end of the thirteenth century, i.e. sixty to eighty shillings would have purchased, and frequently did purchase, two tuns of 252 gallons each. This low price of wine was partly due to the fact that French wine was freely consumed in England six hundred years ago, partly to the political connection which subsisted between this country and Guienne up to the latter part of the fourteenth century. After the rupture of the peace of Bretigny, and the reduction of Guienne, French wine became much dearer. [WINE.]

Priscillianists. In Ecclesiastical History, a sect of the fourth century; so named from Priscillian, a Spanish bishop, put to death in A.D. 382 by Maximus, tyrant of Gaul, on the accusation of another bishop, Ithacius; the earliest instance of anyone put to death for heresy. The opinions of Priscillian and his followers are said to have been Manichæan; but it is remarkable that Sulp. Severus, himself sufficiently zealous against their doctrines, admits that their persecutor Ithacius was a man of disreputable character, and that purity and austerity of manners were often sufficient with him to ground an accusation of Priscillianism. This affords a curious parallel with the history of the twelfth and thirteenth centuries, when accusations of Manicheism were liberally brought against sectaries whose avowed tenets extended only to the reformation of ecclesiastical matters and denial of the church's authority. (Milman's *Latin Christianity*, bk. ii. ch. iv.)

Prism (Gr. πρίσμα, from πρίω, *I saw*). In Dioptrics, a piece of glass or other diaphanous substance, more or less long, with triangular ends, employed to separate a ray of light into its constituent parts or colours by refraction. The prism is the instrument by means of which many of the remarkable phenomena of light and colours are exhibited. [CHROMATICS; OPTICS; REFRACTION.]

PRISM. In Geometry, a polyhedron, two of whose faces are equal, similar, and parallel, while all the rest are parallelograms. Prisms take particular names from the figures of their ends, or opposite equal and parallel sides. When the ends are triangles, they are called *triangular* prisms; when the ends are square, *square* prisms; when the ends are pentagonal, *pentagonal* prisms; and so on. A *right* prism has its sides perpendicular to its ends; an *oblique* prism is that of which the sides are oblique to the ends. The solid content of a prism is found by multiplying the area of the base into the perpendicular altitude; hence all prisms are to one another in the ratio compounded of their bases and altitudes.

Prismatic Analysis. The resolution of a beam of light into its constituent rays of different refrangibility. [CHROMATICS; SPECTRUM ANALYSIS.]

Prismatic Colours. The colours produced by decomposing light by a prism. [PRIMARY COLOURS and CHROMATICS.]

Prismatic Compass. A surveying instrument, much used, on account of its convenient size and form, in military sketching, and for filling up the details of a map where

great accuracy is not required. The construction is as follows: The compass-card, divided into degrees and minutes, is attached to the needle and turns with it. On one side of the compass-box stands a perpendicular slip, called the *sight-vane*, having a long narrow perpendicular slit in it, along the middle of which a fine thread is stretched. On the side of the box opposite to the sight-vane, there is a prism, through which and through the sight-vane an object is observed, and bisected by the thread. The use of the prism is this: the rays of light passing from the thread to the eye are refracted in passing through the prism, so that the thread appears to be prolonged and to intersect the circle on the card on which the divisions are; consequently, the magnetic azimuth of any object which the thread bisects is indicated immediately by the division with which the thread coincides. The angle between two stations is thus obtained, being equal when the stations are on opposite sides of the meridian to the sum of their azimuths, and to the difference of the azimuths when they are on the same side of the meridian. The card is divided to 15′ of a degree, which is, perhaps, a smaller angle than can be measured by this instrument. (Simm's *Treatise on Mathematical Instruments*.)

Prismoid. An imperfect prism; a figure resembling a prism, but not answering exactly to the definition.

Prison (Fr. prendre, *to take*). Imprisonment is commonly used in civilised states for three purposes: for safe custody of persons charged with offences, for the detention of debtors, and for punishment; under which latter head the reformation of prisoners must be comprehended, as an adjunct to punishment. The first principles of order seem to require that these three classes of prisoners should be kept entirely distinct, and, if possible, in separate places of confinement; but even the former rule has been generally very imperfectly observed, while the latter is in most places impracticable by reason of expense. The alleviation of the horrors of imprisonment, by physical improvement of the condition of prisoners and the imparting of religious instruction, has been from very early times an object with philanthropists; but the adaptation of imprisonment to serve the end of punishment has been, comparatively speaking, only very recently attempted. The Society of the Brothers of Mercy, in Italy, paid much attention to the former subject in the fifteenth and sixteenth centuries; and the names of Carlo Borromeo and Vincent de Paul have derived from it much of their lustre. But the earliest instance of a prison managed on any principles of policy and humanity seems to be that of the Penitentiary at Amsterdam, erected in 1595; an example which was soon followed by some of the German towns, especially Hamburg and Bremen. In England it is well known that the impulse of prison improvement was first communicated by the celebrated Howard, whose sufferings, when taken by a privateer and imprisoned at Brest, during the Seven Years' War, are said to have first directed his attention to the subject. The fruits of his observations, in his repeated visits to most of the prisons of Europe, were given to the world partly in his publications, and partly on examination before a committee of the House of Commons in 1774. To his suggestions, and those of Jonas Hanway, are principally owing the provisions of the 19 Geo. III. c. 74 (passed in 1778), truly called the basis of succeeding legislation on the subject. Solitary imprisonment was then first instituted. The works of Neeld and others, and the labours of the Prison Discipline Society (founded, we believe, chiefly by Mr. Fowell Buxton), kept the attention of the public fixed on the subject. In 1813, the construction of the Millbank Penitentiary was begun. This establishment was designed to serve as a species of model prison; but from many errors committed in its foundation and first management, it was long before it answered in any degree the views of its projectors. Meanwhile practical improvement has proceeded much further in the United States of America, where the experiments of solitary confinement and of association in silence were both first instituted on an extensive scale, and have formed the basis of two different systems, which now divide the suffrages of observers. Europe took in this matter lessons from America; and the reports of French visitors to its prisons, especially Messrs. Beaumont and De Tocqueville, 1834, contributed largely to the formation of public opinion on the subject. In 1834, inspectors were appointed to report annually on the state of English and Scottish prisons—a measure which had been earlier adopted with reference to Ireland. The chief heads of improvement in prison discipline then recommended or introduced were: 1. Inspection and control; 2. Classification; 3. Separate or solitary punishment; 4. The *silent* or non-intercourse system; 5. The introduction of labour; 6. Religious and intellectual instruction.—1. The first of these is matter rather of practical than theoretical developement. The history of the plan originally suggested by Sir Samuel Bentham and his brother, Jeremy Bentham the philosopher, which has formed, to a certain extent, the basis of later experiments, is mentioned under the head Penitentiary. 2. Classification, under the English Gaol Acts of 1823 and 1824, has been extensively introduced into prisons. It is, of course, a great improvement on the indiscriminate mixture of prisoners of all classes and characters which formerly prevailed; but as a means of reformation, or of punishment, it has not answered the views once entertained of it. And the reason is obvious: the only object of classification is the exclusion of the moral influence of more or less corrupted minds; but by no system of classification (and as many as fifteen classes have been introduced in some prisons) can this be excluded. In every class, whether arranged according to age,

or degree of offence, or in any other practicable mode, there will probably be some unusually depraved characters; and then the experiment must fail. The only perfect classification is that which constitutes the basis of, 3. The *separate* system; namely, the entire separation of prisoners from each other in solitary cells. When this has been carried to excess as a means of punishment, namely, seclusion by day and by night, without labour, without employment, with only the occasional silent visits of the turnkey or the medical attendant, it has generally proved more than human nature can bear, at least for any considerable time; but separate confinement *with* labour as an alleviation, and with occasional visits for religious instruction, is a very different mode of treatment. The separate system was specially established in the great eastern penitentiary of Philadelphia, and in that of Glasgow. 4. The difficulty of enforcing solitary confinement, in some American prisons, seems to have led to the adoption of the *silent* system: of which the prison at Auburn, in Pennsylvania, affords the most celebrated instance. The prisoners work together in the day, but are prevented from all communication: at night they are separate. It was, we believe, introduced several years ago in the Maison de Force at Ghent. In England, it is in operation at Coldbath Fields, Wakefield, and elsewhere. With respect to the comparative advantages of the two systems, the work of Messrs. Beaumont and De Tocqueville may be consulted for an impartial summary of evidence, without the expression of decided opinion. (Part i. chap. ii. s. 3.) The chief objections to the separate system are: (1) As a punishment, its inequality, being felt far more severely by some than others; but to this it may be answered, that those who do feel it are precisely those whom it is most desirable to affect—the more depraved. (2) Its effects on the mind and passions; a very difficult and delicate subject, and by far the most serious charge against it. (3) That even as a system of reform, for which, in subjects presenting any prospect of amendment, it is best calculated, it is utterly useless in short terms of imprisonment. To the silent system, its enemies object: (1) The extreme difficulty of carrying it into successful operation. (2) Its supposed effect in irritating, degrading, and even brutalising the minds of prisoners, by its vexatious discipline. They appeal in support of this position to the quantity of punishment (corporeal, or by solitary confinement) which is required to carry it into effect. 5. With respect to the introduction of *labour* into prisons of punishment, the chief question seems to be, whether it ought to form part of the punishment, and be of a vexatious and severe nature; or whether it should be used as an alleviation to the rigour of separate confinement and preparation of the criminal for re-entrance into society. The former is the principle commonly adopted in England; the ordinary sentence, for many offences, being imprisonment with *hard* labour, and with occasional intervals of solitary confinement; the treadwheel being the most common species of labour. On this subject the reader may consult the *original* article 'Prisons' in the *Ency. Brit.*; but the views of the author are somewhat too dogmatically expressed. The policy and practicability of making prison labour pay or contribute largely towards the maintenance of the prison has not been much discussed in England, where, from our less economical habits, the experiment has hardly been tried. In America several, it is said, afford a revenue to the state. (De Tocqueville, *Du Système Pénitentiaire aux États-Unis.*) In Belgium they have long been rendered very productive; the works of the present very able inspector-general, M. Ducpétiaux, contain ample information on the subject. It appears also, from various reports of the Irish prison inspectors, that the cost of work has been from time to time more than repaid by the return in every prison; but it does not appear clearly what is comprehended under the former head, and the numbers seem not altogether accurate.

By the Act 2 & 3 Vict. c. 56, *separate* confinement was for the first time distinguished from the severer punishment of *solitary* confinement, and the justices were empowered to make rules for classification, &c., subject to the approval of the secretary of state.

The discontinuance of transportation, except to a very limited extent in 1853, and the substitution of the punishment of *penal servitude*, made prison discipline a matter of even more importance than it had previously been. The result of observation of the *separate system* in the *model prison* at Pentonville ended in its being reduced to nine months for men and a year for women (1854), except in cases of short sentences of one or two years, it being held that the whole of a *short* imprisonment might be beneficially passed in this manner. The labour of prisoners has been devoted, as far as practicable, to the construction of public works. In 1857, after much oscillation of opinion, the principle of remitting part of the sentence for good behaviour was adopted by government: a scale of remissions being introduced in proportion to the length of the sentence. The Irish system of convict discipline is said to go further in the direction of relaxation than the English, 'bringing the convicts nearer to the condition of free citizens.' For the latest discussions on this subject, see the Evidence appended to the Report on Secondary Punishments of the Commission of 1864; and for the system designed to effect the amendment of the juvenile criminal population in separate establishments, see REFORMATORY.

Prisons, Mamertine. Places of confinement in ancient Rome, chiefly intended for state prisoners. They were constructed of large uncemented stones; and, from the specimens of them which remain, it is difficult to imagine a more horrible place for the confinement of a human being. There were two apartments, one above the other, to which

there was no entrance except by a small aperture in the upper roof; and a similar hole in the upper floor led to the cell below, there being no staircase to either. The upper prison was 27 feet long by 20 wide, and the lower, which was elliptical, was 20 by 10; the height of the former was 14 feet, of the latter 7.

Pristis (Gr. πρίστης). The sawfish. The common species of this genus of sharks (*Pristis Antiquorum*, Linn.) bears a process developed from the premaxillary, which measures one-third of the length of the body, and has on each side from twenty to thirty elongated conical teeth. The fish itself is often from twelve to fourteen feet in length.

Privateer. A vessel belonging to one or more private individuals, sailing with a license from a belligerent government, in time of war, to seize and plunder the ships of the enemy. It is obviously an abuse for the vessels of a neutral community to be so employed. But whether the vessel of a neutral state, armed with a commission from a belligerent, can be treated as a pirate, seems as yet an undecided question in the law of nations. (Phillimore's *International Law*, vol. i.) The practice of granting commissions to privateers first became general in the war between Spain and the revolted Netherlands, at the end of the sixteenth century; when it was extensively made use of by the prince of Orange as a means of annoying the Spanish trade.

By the treaty of Paris, in 1856, privateering was abolished as between the principal European nations. Whether, however, this abolition would hold good in actual war may reasonably be doubted, for privateering is the natural resource of a weak power against a superior adversary possessing a wealthy commercial marine. [MARQUE, LETTER OF.]

Privet (altered from prymet, *the primrose*, through a confusion between this flower and the shrub, to both of which the mediæval writers applied the Latin name ligustrum: Prior). The name of a common garden shrub, referred by botanists to the genus *Ligustrum*. The Common Privet, *P. vulgare*, is very frequently used for making dwarf hedges. The berries yield a black dye, used in preparing kid-skins for gloves.

Privilege (Lat. privilegium: defined by Cicero, lex privato homini irrogata). In the ordinary acceptation of the word, a law, or an exception from the common provisions of law, in favour of an individual or a body. Privilege is said to be personal or real; i. e. attached to the person only, or to the person in respect of a particular place; as to a member of one of the universities, an officer of one of the courts at Westminster. The privileges chiefly recognised by the English law are privilege of parliament [PARLIAMENT], and the privilege from arrest allowed to counsel, attorneys, and witnesses attending the courts of justice.

Privity. In Law, a peculiar mutual relation which subsists between individuals connected in various ways; so that, besides those who are actually parties to a transaction, others connected with these parties are said to be privy to the transaction, and are bound by its consequences. Several sorts of privity are enumerated by writers on law; but those of most ordinary occurrence are three: privity of blood, of estate, and of contract. The former subsists between an ancestor and his heir: the second between lessor and lessee, tenant for life and reversioner created by the same instrument; and privity of contract between those who are parties to a contract, which species of privity is personal only.

Privy Chamber, Gentlemen of the. Officers of the king's household, instituted by Henry VII. Their duties are to attend the sovereign; but the appointment is now merely honorary. There are also four gentlemen ushers of the privy chamber, whose office is to wait in the presence chamber, attend on the king's person, and note affairs under the lord chamberlain and vice-chamberlain.

Privy Council. [COUNCIL, PRIVY.]

Privy Seal, Lord. The fifth great officer of state in England, who has the custody of the privy seal of the king, used for all grants, charters, pardons, &c. before they come to the great seal. For the present practice, see SEAL.

Prize (Fr. prise, *a booty*). In International Law, anything captured by a belligerent using the right of war; in common language, only ships thus captured, with the property taken in them, and booty taken by an army, are so called. Prizes taken in war are condemned by the proper judicature in the courts of the captors: such condemnation is held to divest the title of the proprietor and to confer a new ownership. In order to give jurisdiction to a court of prize, it is deemed necessary, by the law of nations, that the property captured should be in possession of the captors in their own ports, those of an ally, or of a neutral; but no belligerent power has a right to capture in the ports of a neutral country, or within a marine league of her shores. Subject to capture are hostile property, i. e. the property of persons domiciled in a hostile country, and neutral property contraband of war. [CONTRABAND.]

The Prize Court in England is constituted by a commission addressed to the Judge of the Court of Admiralty [ADMIRALTY], the jurisdiction of which as respects naval prize has been recently defined and remodelled by the Naval Prize Act, 1864. Questions relating to *booty of war*, i. e. prize taken by land forces, are occasionally referred by the crown to the same court.

Prize Money. The proceeds of a prize on its sale. The money is divided among the captors in specified proportions, according to rank. In the case of a ship-of-war captured from a foreign power and adopted into the navy of the capturing nation, an allowance per gun is made as prize money to the captors.

Pro Re Natâ (Lat. *as occasion may require*). A term commonly used in medical prescriptions.

Pro-Hessian. The homogeneous equation of a developable of the n^{th} order contains a quaternary n-*ic* whose Hessian is of the order $4(n-2)$ in the variables. Now every point of a developable being a parabolic point reduces the Hessian to zero, so that the latter contains the original n-*ic* as a factor. The remaining factor of the order $3n-8$ is called the *pro-Hessian*. [DEVELOPABLE SURFACE; HESSIAN.]

Proa, Flying. A narrow canoe, about thirty feet long by three feet wide, used in the Ladrone Islands. The lee side is flat, being the mere longitudinal section of the common form, and the head and stern exactly alike. A slight framework projects several feet to windward, bearing a small block of wood like a canoe: this float supports the vessel from oversetting to leeward, as she would otherwise do, and the framework affords support for a weight acting against the pressure of the sail. The vessel is steered by a paddle at either end, and moves with great velocity, either backwards or forwards, being adapted to a side wind in running between two places. The sail is mat, with a boom, upon one mast. *Proa* is also the name for large boats used by the Malays, propelled both by oars and sails.

Proaulion (Gr. from πρό, and αὐλή, *a hall*). In Ancient Architecture, the same as a VESTIBULE.

Probabilism (Lat. probabilis, *likely*). In Theology and Ethics, a theory professed by some casuistical divines, chiefly of the Jesuit order, according to which it is lawful to follow a *probable* opinion in doubtful points, although other opinions may seem to the mind of the enquirer more probable. Those who teach this doctrine are styled *Probabilists*. This and the other tenets of the once celebrated science of casuistry are ably touched on by Mr. Hallam, in his *Literature of Europe* (pt. iii. ch. iv. § 13).

Probability, Theory of. A very extensive and important application of analysis, having for its object the determination of the number of ways in which a future or uncertain event may happen or fail, in order that we may be enabled to judge whether the *chances* of its happening or failing are the greater, and in what proportion.

In this theory the word *chance* is used to signify the occurrence of an event in a particular way, when there exist two or more ways by which it may take place, and no reason can be assigned for its happening in one way rather than another. In ordinary language, when an event is said to happen by chance, it is merely implied that the cause is unknown, or cannot be certainly appreciated.

The term *probable*, in its common acceptation, is applied to any contingent or future event, to denote that in our judgment the event is more likely to happen than not to happen. In mathematical language *probability* has a definite signification, and, if all chances are considered equal, it is measured by a fraction, the numerator of which expresses the number of chances favourable to the occurrence of the event, and the denominator the whole number of chances favourable and unfavourable.

Every contingent event gives rise to two opposite probabilities: one, that the event will happen; the other, that it will not; and the sum of these probabilities, which necessarily amounts to certainty, is always equal to unity.

Hence if p denote the probability of the occurrence of an event, the probability that it will not occur is $1-p$.

The probability of the simultaneous occurrence of several independent events is obtained by multiplying together their separate probabilities. Thus, let p denote the probability of an event A, q that of an event B, r that of an event C, &c.; then the probability of the joint occurrence of those events is expressed by the continued product $p\,q\,r$, &c.

The probability of the successive recurrence of the same event or of different events is determined in a similar manner. Thus, suppose m to be the number of white balls in an urn, and $n=$ the number of black balls in the same urn, and that when a ball has been drawn it is immediately replaced in the urn, so that at each trial the whole number of chances is $m+n$. Let $p=$ the probability of drawing a white ball on any trial, and $q=$ the probability of drawing a black ball; we have then

$$p=\frac{m}{m+n},\ \text{and}\ q=\frac{n}{m+n}.$$

And first let us consider the probabilities of the different possible events that may happen on two trials.

The only possible ways in which the balls can be drawn in two successive trials are these four:—

1. First white, second white; probability $=p\times p=p^2$;
2. First white, second black; probability $=p\times q=p\,q$;
3. First black, second white; probability $=q\times p=p\,q$;
4. First black, second black; probability $=q\times q=q^2$.

Adding together these probabilities, we get

$$p^2+2\,pq+q^2=(p+q)^2,$$

and the sum is equal to unity, as will be evident by substituting for p and q their values in terms of m and n.

It thus appears that the probabilities of all the different combinations that can be formed in two trials are respectively given by the developement of the binomial $(p+q)^2$. It will be observed that the term $2\,p\,q$ gives the probability of drawing a ball of each colour in the two trials without distinction of order; i. e. the white ball may be drawn either at the first or second trial.

Now, let the number of trials, instead of being two, be increased to any number u; the probabilities of the different combinations will be given by the developement of the binomial $(p+q)^u$. This developement is

$$p+\frac{u}{1}\ {}^{u-1}\,q+\frac{u(u-1)}{1.2}\,p^{u-2}\,q^2\ \ldots\ldots$$

$$+\frac{u(u-1)\,(u-2)\ \ldots\ (u-v+1)}{1\ .\ 2\ .\ 3\ \ \ \ldots\ \ \ v}\,p^{u-v}q^v+\text{\&c.}$$

The first term p^u indicates the probability of drawing a white ball in each of the u trials, or that all the balls drawn will be white. The second term $u p^{u-1} q$ denotes the probability of drawing $u-1$ white balls and one black ball in u trials without regard to the order; i. e. the black ball may be drawn at the first, second, third, or any other trial. The general term

$$\frac{u(u-1)(u-2)\ \ldots\ (u-v+1)}{1\ .\ 2\ .\ 3\ \ldots\ v} p^{u-v} q^v$$

gives the probability that in u trials $u-v$ white balls will be drawn, and v black balls, without distinction of order. If the probability of drawing the ball in a determinate order of succession were required; for instance, if it were required to determine the probability of drawing $u-v$ white balls successively, and then v black balls; the coefficient of the term must be suppressed, and the probability becomes $p^{u-v} q^v$.

The practical question most frequently arising is, not to determine the probability of the repetitions of an event in any precise order, but the probability that the number of repetitions will exceed or not exceed a certain limit. Thus, in the preceding example, suppose it were required to assign the probability that not fewer than $u-v$ white balls will be drawn in u trials; it is evident that as the first term gives the probability of drawing u white balls, the second term that of drawing $u-1$ white balls, and so on, and as each of these combinations satisfies the condition, the required probability will be found by taking the sum of all the terms of the developement of $(p+q)^u$ from the first to that in which the factor $p^{u-v} q^v$ appears, both inclusive.

In what precedes it has been supposed that the number of ways in which an event can arrive are known à priori; but it may happen, and indeed does happen, in the greater number of the most important questions to which the calculus of probabilities is applied, that the number of chances favourable and unfavourable to the occurrence of any particular event is unknown, and that the ratio of the one to the other can be inferred only from considering the ways in which the event has been observed already to happen. For instance, we may suppose an urn to contain a certain number of balls of different colours, the number of each colour being unknown, and that, from having observed the result of several trials, we have to determine the probability of drawing a ball of a particular colour at the next trial. The general method of proceeding in such cases is as follows: Let c, c', c'', c''', &c. be so many independent causes (or hypotheses), each of which may give rise to an event E; and let the probabilities of the existence of these causes be respectively h, h', h'', h''', &c., and those of the events calculated according to each hypothesis p, p', p'', p''', &c.: then the probability of the event E is $hp + h'p' + h''p'' + h'''p''' +$ &c.

The preceding examples will suffice to give some idea of the manner in which the probability of the occurrence or failure of events depending on chance is submitted to numerical estimation; but for the methods of applying the calculus in particular cases, and especially when the formulæ involve high numbers and the ordinary processes of arithmetic become unavailable, reference must be made to works specially devoted to the subject, a list of which is given at the end of this article.

The calculus of probabilities had its origin in the speculations of Pascal, Fermat, Huygens, and other eminent mathematicians of the seventeenth century. It was first applied to the solution of questions connected with games of chance; but it has since, by the researches of James Bernoulli, Montmort, De Moivre, D'Alembert, Simpson, Condorcet, Lagrange, La Place, Poisson, and others, become one of the most interesting branches of mathematics, and has been applied with equal success and advantage to numerous important questions belonging to natural and political philosophy. One of its most familiar and useful applications is to the subject of annuities, assurances, reversions, and other interests depending on the average duration of human life, and the expectation of the continuance or survivorship of lives of given ages. [ANNUITY; EXPECTATION OF LIFE; MORTALITY, LAW OF.] Another important application is to determine the most probable *mean*, or average, of a great number of observations; and hence its utility in many cases of practical astronomy and general physics. [PROBABLE ERROR.] Condorcet has applied it to determine the value of testimony, the verdicts of juries, and the best mode of constituting tribunals, and of collecting votes in elections. In such applications, it is true, assumptions more or less arbitrary must be admitted, and great uncertainty will always attach to results which are influenced by human will or caprice; nevertheless, the knowledge derived from an accurate and systematic analysis of the circumstances concerned, and of the consequences of their various combinations, affords important aid in guiding our judgments, and may be of great use in the practical affairs of life.

The following are the principal works on the subject: Montmort, *Analyse des Jeux de Hasard* (1st edit. 1708; 2nd, 1713); Bernoulli, *Ars Conjectandi*, 1713; De Moivre, *Doctrine of Chances* (1st edit. 1718; 3rd, greatly enlarged, 1785); Simpson, *Laws of Chance*, 1740; Condorcet, *Essai sur l'Application de l'Analyse à la Probabilité des Décisions rendues à la Pluralité des Voix*, 1785; La Place, *Théorie Analytique des Probabilités*, 3rd edit. 1820; Poisson, *Recherches sur la Probabilités des Jugemens*, 1837; the article in the *Ency. Metrop.* by Professor de Morgan, and that in the *Ency. Brit.* by Mr. Galloway (which is published separately). For elementary works, the reader may be referred to Simpson's *Laws of Chance*, and Lacroix's *Traité Élémentaire*, &c.; and for an explanation of the objects and results of the science, without mathematical investigation, to

Professor de Morgan's 'Essay on Probabilities, and on their Application to Life Contingencies and Insurance Offices,' in the *Cabinet Cyclopedia.*

Probable Error. In Astronomy and Physics, when the value of any quantity or element, as the declination of a star, the latitude of a place, the specific gravity of a body, &c., has been determined by means of a number of independent observations, each liable to a small amount of error, the determination (in whatever way it may have been deduced from the observations) will also be liable to some uncertainty; and the *probable error* is the quantity which is such that there is the same probability of the difference between the determination and the true absolute value of the thing to be determined exceeding or falling short of it. Thus, if twenty measurements of an angle have been made with the theodolite, and the arithmetical mean or average of the whole gives 50° 27′ 13″; and if it be an equal wager that the error of this result (either in excess or defect) is less than 2 seconds, or greater than 2 seconds, then the probable error of the determination is 2 seconds. The method of computing the probable error, which is deduced from the theory of probability, is as follows: Let l, l', l'', &c. be the *observed* values, h the number of observations, m the average value (i.e. the sum of the observed values divided by number of observations); then if we call $l-m$ the error of the observation l, and $\Sigma(l-m)^2$ the sum of the squares of the errors of all the observations, the probable error is

$$\cdot 674489 \times \frac{\sqrt{\Sigma(l-m)^2}}{h};$$

i.e. the square root of the sum of the squares of the errors, divided by the number of observations, and multiplied by the decimal ·674489.

It is frequently convenient to compute the probable error of a result from another function, which is called the *weight.* The weight is the square of the number of observations divided by twice the sum of the squares of the errors; and the probable error is ·476936 divided by the square root of the weight. This definition agrees with the former, for

$$\cdot 674489 = \cdot 476936 \times \sqrt{2}.$$

Probang. A flexible piece of whalebone with a ball of sponge attached to its extremity, used for the purpose of removing obstructions in the œsophagus.

Probate of a Will. In Law, the exhibiting a will before the proper court by the executor, and obtaining a *proved* copy thereof, is termed obtaining *probate.* The present Court of Probate was established in 1857 (20 & 21 Vict. c. 77), with jurisdiction to grant letters of administration of the effects of persons dying intestate, and probate of the wills of testators; the powers of the ecclesiastical courts in these matters being abolished. The court is presided over by a single judge, from whom an appeal lies direct to the House of Lords; so far as personal property is concerned, it has exclusive jurisdiction in all questions relating to the competence of a testator or the due execution of his will. The probate copy of a will forms the authoritative instrument on which the executors act, the original will being retained in the registry of the court, where an official copy of it may be inspected by any person on payment of a fee of one shilling.

Probe (Lat. probo, *I try*). A surgical instrument, generally made of silver wire, rounded at one end and pointed at the other, used for the purpose of examining wounds.

Problem (Gr. πρόβλημα). In Geometry, a proposition requiring some operation to be performed or construction to be executed; such as to bisect a line, to describe a circle passing through three given points.

Proboscidians. The name of a family of Pachydermatous Mammals, including those which have the nose prolonged into a prehensile trunk or PROBOSCIS; as the elephant and mastodon.

Proboscis (Gr. προβοσκίς, from βόσκω, *I feed*). In Entomology, the oral instrument of the Diptera is so called, in which the ordinary trophi are replaced by an exarticulate sheath, terminated by a pair of tumid lobes (labella), and containing one or more lancet-shaped instruments (scapella), covered by a valve.

PROBOSCIS. In Malacology, this term is applied to the tongue of certain Gastropods, when it is so long as to be capable of being protruded for some distance from the mouth; in which case it is generally organised at the extremity for the purpose of boring the shells of other testacea, and of destroying by suction the soft parts of the inhabitant.

PROBOSCIS. In Mammalogy, the prehensile organ formed by a prolongation of the nose, of which the trunk of the elephant is an example.

Procedendo or **Procedendo in Loquelâ.** In Law, a writ which lies where an action has been removed from an inferior to a superior jurisdiction on insufficient grounds, to send the cause back to the inferior court for further proceeding.

Procedendo ad Judicium. A writ which issues out of the Court of Chancery, commanding inferior courts to proceed to judgment where it has been unjustly delayed. This is practically superseded by the writ of mandamus from the Queen's Bench.

Procellariæ (Lat. procella, *a storm*). A Linnæan genus of web-footed birds, now the type of a family of the *Longipennate Palmipedes* in the system of Cuvier, characterised by the beak being hooked at the tip, with its extremity appearing as though a piece had been articulated to the rest; the nostrils are united to form a tube, which lies along the back of the upper mandible; and their feet, instead of a back toe, have merely a claw implanted in the heel. Those species in which the lower

mandible is truncated belong to the true *Procellariæ*. Some smaller species, with a shorter bill, rather longer legs, and black plumage, commonly called *Storm-birds*, or *Mother Carey's chickens*, are associated under the generic name *Thalassidroma*. The *Procellariæ* range over the high seas at the greatest distance from land. Their name of *Petrel*, which is a diminutive of *Peter*, has been applied to them from their habit of walking on the waves, which they appear to do with the assistance of their wings.

Procès-Verbal. In the language of French Jurisprudence, an authentic written minute or report of an official act or proceeding, or statement of acts. The term is also used to signify minutes drawn up by a secretary or other officer of the proceedings of an assembly.

Process. In the language of English Common Law, this term is used in two senses, to signify (1) the whole proceedings in an action or prosecution; and (2) the means whereby the defendant in an action is compelled to appear in court. When actions were commenced by original writ, original *process* was that which was founded on that writ, commencing with notice, writ of attachment, &c. *Mesne*, or intermediate process, was, properly speaking, such process as issued pending the writ on some collateral or interlocutory matter; as to summon juries or witnesses. But in popular language it was taken to signify the whole process, from the commencement of the suit, before the final process which ended it. Thus a defendant was said to be arrested on *mesne* process, i.e. on a writ of capias issued *pending* the suit. This was done originally when the defendant, being summoned, or attached, neglected to appear or made default. In course of time, by a legal fiction the summons and neglect were supposed; and the writ of capias became the commencement of the proceedings, to which the term *mesne process* was still inaccurately applied. The term *mesne process* is now commonly applied to the writ of summons, which is the instrument now in use for commencing personal actions. Thus the popular inaccuracy of language is retained. *Final* process is the writ of execution used to carry the judgment into effect. In ordinary language, the regular proceedings of every court of judicature in a suit are called its *process*.

Proclamation (Lat. proclamatio, *a calling out*). Public notice given by the king to his subjects. [KING; PRIVY COUNCIL.] The power of issuing proclamations is a branch of the king's prerogative, and vested in him alone. They have a binding force on the subject, in so far as they are grounded on and enforce the laws of the realm. They may be said to be of two sorts: the one, enforcing an actually existing law by giving it a particular application of time, place, and circumstance; the other, exercising an extraordinary power vested in the king, which until so exercised is dormant; as a proclamation to prohibit any subject from leaving the realm during a certain time. Proclamations must be under the great seal. By 31 Hen. VIII. c. 8 it was enacted that the king's proclamations should have the force of law: an enactment which, while it subsisted, did, in effect, make a complete revolution in the government of this country. It was, however, repealed five years afterwards by 1 Edw. VI. c. 12. Nevertheless, in later times, it was held by crown lawyers, that the king might suspend or dispense with an existing law in favour of particular circumstances. But by 1 Wm. & Mary stat. 2 c. 2 it is declared that no such power exists.

Procœlian (Gr. πρό, *before*; κοῖλος, *hollow*). In Anatomy, those vertebræ are so called which have a cavity or cup at the fore part of the body, and a ball at the back part. The term is also applied to a group of animals—e.g. a certain family of reptiles which manifest this vertebral character. It is found in most existing Saurians, but not in any extinct terrestrial species of earlier date than the Wealden period. The oolitic Pterodactyls were procœlian.

Proconsul. Originally an officer invested with consular command without the office. Thus, a consul sometimes had his command prolonged to him after his year of magistracy had ceased, with the title of *proconsul*. The provinces which at first were governed by prætors were, for the most part, subsequently put under *proconsuls* and *proprætors*, who were at first especially appointed at the Comitia Tributa; but afterwards, by the Sempronian law, they entered on their provincial jurisdictions forthwith, on the expiration of their year of consulship or prætorship. The office was properly annual; but it might be prolonged, as was done in the case of Cæsar. In the time of the republic the proconsul held the military command as well as the civil jurisdiction of his province, and accordingly had about him a large staff of officers, as the lieutenants or legati, præfects, &c. But Augustus, on assuming the chief power in the state, remodelled the system by a new partition of the provinces, and by separating the civil jurisdiction, which was left to the proconsul, from the military command. Under the emperors, the proconsuls and proprætors were distinguished by the former being appointed to the provinces under the especial superintendence of the senate; the latter, with the title of *legati Cæsaris*, to those which the emperor held.

Procris (Gr.). This beautiful creation of mythical speech is described in the Athenian tale as a daughter of Erechtheus; but in unconscious fidelity to the old phrase her mother is still Hersê, the dew. In the spring time of her youth, she wins the love of Kephalos (Cephalus), a chieftain of Phokis (Phocis), who is also loved by Eos. By the persuasion of the latter, Kephalos is at last tempted to try the constancy of Procris; he therefore leaves her, and after a while coming to her again in disguise, succeeds in gaining her affection.

On discovering her shame, Procris flies to Crete, where Artemis gives her the spear that never misses its mark, with the hound which attended her in the chase. These gifts are coveted by Kephalos, to whom Procris (disguised in her turn) refuses to give them except in exchange for his love. They are thus reunited; but the unerring spear in the hand of Kephalos soon smites Procris, who was hidden by the thick bushes; and Kephalos, journeying westwards, in his sorrow, reaches the Leucadian cape, whence he sinks into the sea. This beautiful legend shows beneath a veil almost transparent the loves of the sun and the dew. Kephalos is the *head* of the sun; while the name Procris is explained by a reference to the Sanscrit *prush* and *prish*, to sprinkle, and thus the myth resolves itself into a few simple phrases. Kephalos loves Procris, as the sun loves the dew; but Eos also loves Kephalos, as the dawn loves the sun. Procris is faithless, yet she gives her love to the same Kephalos, as the sun shines reflected from the various dewdrops. Procris lastly is killed by Kephalos, as the dew is absorbed by the sun. For a further analysis of the myth, see Max Müller, *Comparative Mythology*, 54; and Cox, *Gods and Heroes*, 49 &c.

Procrustes (Gr. προκρούστης, *the stretcher*). In Greek Mythology, a surname for the robber Polypemon or Damastes, who placed his victims on a bed which was either too small or too large, and to the size of which he adapted their limbs by force. He was slain by THESEUS.

Proctor (Lat. procurator). In Ecclesiastical Law, he who undertakes for his fee to manage a cause in the ECCLESIASTICAL COURT.

In the English Universities, both at Oxford and Cambridge, two masters of arts are appointed annually to the office of proctor. Each college, in both (and at Oxford the halls collectively), nominates a proctor in rotation according to a cycle of years drawn up on mathematical principles, the basis of the calculation being the average number of masters of arts on the books of each society. The proctors are officers of considerable importance; being, in the first place, the chief police magistrates for the time being of each university. With their deputies the pro-proctors, they have not only power to enforce the rules of academical discipline on the students, but also an extensive summary authority over the townspeople, according to the special privileges of the universities. They also have, in both universities, peculiar legislative authority as assistants to the heads of houses, and official votes in the election of many professors and other officers. The proctors must be masters of arts, and their standing as such, at Oxford, from four to fifteen years. Originally the functions of the proctor in the universities consisted in the management of academical funds, both those collected by the bedels from all members of the university, and those which were derived from estates either possessed by the university in its own right, or held in trust by the university for particular corporations. Hence, conjointly with the chancellor, they kept the keys of the academical treasury, and their formal admission to office was accompanied by the delivery of these keys. One of these treasure chests is preserved in the picture gallery of the Bodleian Library at Oxford, and is fastened by a lock which springs twelve or fourteen bolts, the key of which was in the custody of the chancellor, and by two padlocks, the two keys of which were kept by the two proctors. The exercise of academical discipline by these officials is of comparatively late date.

As the universities discouraged the study of the common law, and adopted the rules of the civil code, in their local jurisdiction, they styled the advocates who were empowered to plead in their courts by this name also. Such persons were called proctors *ad lites*, their chief function being that of suing out process for debts. Till within the last few years, this office was filled at Oxford by masters of arts, but by a late change attorneys at law are admissible to practice, on nomination from the vice-chancellor.

The representatives of the clergy in Convocation are also called *proctors*, because they were intrusted with the assessment of taxes granted by that body. Originally, the proctors in Convocation received wages, as did the knights of the shire and the burgesses of parliamentary towns.

Procurator (Lat. pro, *for*, and cura, *care*). A Roman provincial magistrate, whose office it was to manage the affairs of the revenue, and exercise a judicial authority in matters pertaining to it. Sometimes the procurator discharged the office of governor, especially in a small province, as did Pontius Pilate in Judæa; in which case, but not otherwise, he had the power of inflicting capital punishment. This magistracy did not exist under the republic, its duties being comprised under those of the prætor or proconsul. Under the emperors these magistrates were called *procuratores Cæsaris*, to distinguish them from the common procurator, who was merely an agent employed by private persons to manage their affairs in their absence when an action was brought against them.

PROCURATOR, PROCUREUR, &c. In the Civil Jurisprudence, one who undertakes the care of any legal proceeding for another, and stands in his place by virtue of a power of *procuration* from him. A *mandatory* is said to differ from a *procurator* in that the latter acts only by virtue of an express written instrument. In France, before the Revolution, the procureurs (procuratores ad lites) were officers legally empowered to carry on suits on behalf of clients. This body was abolished in 1791, and that of *avoués* substituted in its place. The *procureurs du roi* in France are officers of whom one is appointed to every tribunal of arrondissement, together with a sufficient number of *substitutes*.

Procurator Fiscal. The title of the public prosecutor in the inferior courts of Scotland. The procurator fiscal, who usually makes the preliminary enquiries as to crimes committed in his district, acts under the lord advocate, who is the principal public prosecutor.

Procureur-Général. The public advocate of the crown in France. Every *parlement* or *cour souveraine* had, before the Revolution, a *procureur-général* attached to it. Under the present system of judicature, one of these officers is established in every *cour royale*, for the criminal part of its proceedings: and under him an *avocat-général*, for the civil department of the court. The public accusers in the inferior courts of assize and *première instance*, are termed respectively *procureurs criminels* and *procureurs d'état*. These officers are charged with the conduct of all criminal proceedings on behalf of the prosecution; and are placed under the immediate control of the minister of justice.

Procyon (Gr. προκύων). In Astronomy, the name given to the brightest star in the constellation of *Canis minor*.

Procyon. In Zoology, a genus of Plantigrade Carnivorous mammalia, of which the common racoon (*Procyon lotor*) is the most notable species.

Prodigy (Lat. prodigium). In ordinary modern language, this word signifies a surprising though natural event; in contradistinction to *miracle*, which denotes something out of the course of nature. Among the Romans, however, any extraordinary event or appearance, to which, from insufficient acquaintance with natural history, they could not assign a cause, was termed a *prodigy*, and regarded as indicating the dispositions of their gods. Hence the number of recorded prodigies which occur in Roman history. [Omens.]

Prodomus (Gr. πρόδομος). In Ancient Architecture, the portico before the entrance of the cella of a temple; the same as *pronaos*. [Naos.]

Produce, Raw. A formula used in Political Economy in a somewhat more limited sense than *raw material*. Thus, sugar, corn, cotton, are called *raw produce*, while ores, timber, dye, &c. would be *raw material*. In the latter case, little or no labour has been expended on the article beyond that which is necessary in order to appropriate it; in the former, some, and often great, labour has been laid out in the cultivation of the article. No precise line, however, can be drawn between the proper use of either term. [Material, Raw.]

Product (Lat. productus, *brought forward*). In Arithmetic and Algebra, the result of, or quantity produced by, the multiplication of one number by another, or a quantity of any kind by a number. [Multiplication.]

Producta (Lat.). An extinct genus of fossil bivalve shells, closely allied to the living genus *Terebratula*. They only occur in the older secondary rocks.

Production (Lat. productio, from produco, *I lead forward*). In Political Economy, the process by which the labour either directly applied by man, or indirectly (i. e. in the guidance given by labour to the muscular powers of animals), and the mechanical powers of certain physical objects, as steam, wind, or running water, are made available for the developement of utilities from the materials and forces supplied by nature. As no labour is possessed of any economical significance unless it be exercised on articles possessing a value in exchanges, and destined to be exchanged, so all production which has an economical value is of commodities in demand. Similarly, a nation will not be stimulated to the production of any commodity beyond its own immediate or habitual wants, and therefore will not enter on any operations in exchange, unless it be offered some article which it desires and cannot produce, or cannot produce so easily and cheaply as other labour can. Thus, when after emancipation the negroes in the British West India islands, having only the lowest and most rudimentary tastes for the conveniences of civilisation, and possessing the means of gratifying them in abundance, were invited to produce commodities by their voluntary labour, the expectation that they would respond to the invitation was necessarily disappointed. But the extension of the desire for the higher class of utilities is a great stimulus to production; and the policy which discouraged, by means of sumptuary laws, any expenditure among the poorer classes of society beyond what was required for the bare necessaries of life, was not only an unwarrantable intrusion upon private liberty, but a great hindrance to economical progress. The neglect of the distinction between the use of the reasonable comforts and conveniences of life in the fullest measure that can be achieved consistently with prudence and economy, and the depraved taste for vicious indulgence, forms the fallacy of Mandeville's paradox that private vices are public benefits, in his fable of 'the bees or knaves turned honest.' On the other hand, mere expenditure is not production, nor a stimulus to production. When Louis XIV. answered Madame de Maintenon, on her requesting him to give alms to the people in a time of scarcity, that the best charity he could give was in spending money, the fallacy was equally irrational; he could only spend on luxury, by taking from poverty. Production in particular articles may be in excess, and in consequence the market price may fall below the cost of labour expended on the article; but there cannot be a general over-production, for this would only mean that everybody had more of everything with less labour. General over-production is, in fact, identical with the phrase *a general glut*, which is a contradiction in terms. [Glut.]

Production, Cost of. It is a fundamental position in Political Economy, that labour which has an economical significance is always undertaken with a view to profit or advantage.

The exchange of produce manufactured with such a purpose is determined by supply and demand, for both of these, if action be free and uncontrolled, are affected by the competition of buyers and sellers, or of production and exchange, the measure of both products being money. If, therefore, that which holds good between individuals affects communities also, the discovery of any means by which the cost of production may be lessened, gives an advantage in trade to the individual or the community which may possess the easier and less costly means of producing the commodity or commodities in which it trades. And as everyone is busied, economically speaking, in getting the largest advantage for the least labour, free action will always strive to diminish to the minimum amount the cost of production in the manufacture of all articles which are demanded and may be supplied, whatever be the form of industry adopted by a community, or presented to it by favourable conditions of soil, climate, and the like.

The two contributories to the cost of production are labour and profit. Rent does not diminish or increase the cost of production, but variations in the cost of production and in the demand for the produce increase and diminish rent. The interest of the landowner is not, therefore, except in a very indirect way, contrary to the interest of the public, as Ricardo thought; but the advantage of the public, and the general prosperity of all classes, is of the highest significance to the interest of the landowner, since it is by the demand for agricultural produce (not, as the authors and supporters of the old corn laws imagined, for grain only, but for all produce), that larger claims can be made for the use of such natural powers as the soil possesses. That rent does not increase the cost of production is manifest; for no one imagines that if all rents were extinguished, population and its demands for agricultural produce remaining the same, prices would fall. The only difference would be, that the whole of the difference between the cost of production and the price at which the produce was sold would become the advantage of the agriculturist; i.e. he would take not only the wages of his labour, the insurance on the risks of his occupation, and the profit of his capital, but indirectly the rent of land. Nor does this affect rent which is derived from land employed in tillage only; exactly the same circumstances belong to land let for building purposes, and occupied in thoroughfares or other localities particularly suitable for business. Rent obtained for such sites does not increase the expense of carrying on such a business, but the business is of such a character as to secure larger advantage to the occupier than could be obtained in a less favourable locality; and as far as this advantage is not due to the intelligence, capital, and labour of the trader, the landlord is enabled by the principle of competition to obtain a share of the commercial fertility of the site, just as he does of the natural fertility of a rich soil.

The cost of labour as affecting the cost of production is measured not necessarily by the wages of labour, but by its efficiency. Low wages may be economically dear, high wages may be economically cheap. The wages of domestic servants in India are very low; but if the aggregate of service obtained by a dozen natives does not equal the effectiveness of one European domestic, the cost of service may be much higher in that country than it is in England. Similarly, if the charge to which a contractor is put in hiring one kind of manual labour is one-half the rate at which another kind of labour may be hired, and the latter kind does treble the work of the former, the latter is cheap, the former dear. So, in a manufactory, the labour of children may be hired for three shillings a week, and that of some artisans employed may be as much as three pounds; but the result of the former kind of labour may not, and often does not, represent so large an advantage as that which is derived from the labour of the latter. It is even possible that a shorter time of labour at equal wages may be more advantageous to the employer, because the gross produce of the labour is larger, as its quality is better; and that which applies to human labour, applies equally to its substitutes. The old-fashioned English cart-horse might fifty years ago have been purchased for five pounds, and might have been kept at five shillings a week. A good modern cart-horse may cost fifty pounds, and require food valued at twelve shillings. But if the power of draught in the old cart-horse was equal only to ten tons, and that of the better bred animal to thirty, it is more economical to employ the latter labour than the former. So with machinery. A threshing machine may cost two hundred pounds; but if the produce of this substitution for human labour represents a gain of twenty per cent. on the old manual labour, it is better to buy or hire the machine than to continue the use of the flail. The same observations apply to reaping and ploughing machines, which can commend themselves to public notice and use only in the event of their performing the services done by manual labour with equal efficiency and at less aggregate cost.

In those countries where the real cost of labour is high, owing to the existence of large and easily procurable tracts of fertile land, and to the scantiness of population, the stimulus to the substitution of mechanical for manual labour is exceedingly strong, and the invention of machinery in aid of human labour is remarkably progressive. The United States have in effect produced many machines which in great degree supersede human labour, and in all cases multiply its efficiency. Such are the sewing machine in private life, and the various agricultural machines which have been adverted to. So great is the demand for such aids, and so abundant is the supply of these aids in substitution or multiplication of human labour in the United States, that, as the writer is informed, though the contribution of the state of Ohio to

the late war was not less than 90,000 males, out of a population of little above two millions, the labour of housing one of the largest harvests ever known in that state, that of 1864, was accomplished easily by the abundant use of agricultural machines. But where labour is cheap and population dense, the stimulant is less vigorous. This comparative indisposition to employ mechanical forces in aid of human labour is most manifest where, as in this country, a legal provision is made for the relief of the poor, the tenure of land is precarious, or at least the tenant is liable to the caprice of the landowner.

The rate of profit or interest has its effect on the cost of production, partly because the producer in so far as he is a capitalist will need to be satisfied by receiving, in the aggregate of what is called his profit, the ordinary rate of interest, partly because in many productive operations much capital is borrowed. If, therefore, the rate of interest is raised by any insecurity felt as to the repayment of the advance, industry is seriously hindered, and undertakings cannot be entered on, or not entered on with ease and safety. With high rates of interest, where the investment is secure and the sole cause of the high rate is the large competition for capital consequent on high rates of profit or advantage, the cost of production is indeed enhanced; but industrial occupations may be carried on with great energy, because wages and profits being high, the borrower receives his benefit in the large payment made for his industry and skill.

It would seem at first sight that a diminished cost of production, consequent on the substitution of mechanical for manual labour, would lower the rate of wages. It is notorious that no such result has ensued, notwithstanding the gradual increase of population in this country, and the considerable employment of these aids. Thus, for instance, one branch of agricultural labour has been almost entirely superseded; that, namely, of hand threshing. Where labour is far short of the demand for it, the possibility of a reduction in wages is remote; if, of course, only one kind of labour could be supplied by an individual, the total cessation of employment in this direction would induce great distress. But it rarely happens that labour, especially that which is dependent on those pursuits in which such results might be anticipated, is of so special and simple a character. The agricultural labourer performs many different functions, and the progress of agricultural science has rather added to than diminished their number by the substitution of machinery. Besides, almost all occupations (those, for instance, which supply machines for agricultural purposes) need a considerable amount of unskilled labour. The construction of railways, an operation as relevant to agricultural as to manufacturing pursuits, has absorbed a large amount of what may be called the surplus population of country districts, and the demand for labour in those regions which are peculiarly manufacturing has occupied many more, the late census indicating a notable decline in the purely agricultural counties. Nor does a diminished cost of production in one branch, or indeed in all branches of agricultural industry, diminish rent, provided the demand be fully commensurate with the increase effected. It must be remembered that an agriculturist is engaged in a large number of operations. It is possible, indeed necessary for the well-being of society in densely peopled countries, that the first necessaries of life should be supplied abundantly by importation from abroad; but it does not by any means follow that the gains of the agriculturist will be diminished, or the rent of the landowner lowered. Neither have been so affected, as we know by facts; the cause of this result, unexpected or disputed when it was only theoretically certain, is to be found in the fact that greater prosperity has given enlarged powers of purchase to the general public.

If a community is maintained, on an average of years, entirely upon the produce of its soil, the number of persons other than agriculturists which the country contains will denote the rate of production, or the cost of producing food. Similarly, if information can be procured as to the general rate of production from given areas at any period in the history of a community, during which no actual or no important supply of food has been introduced from a foreign country, the evidence so obtained will be a fair basis on which to conclude what was the population of a country, in the absence of any direct evidence derived from an enumeration or census. Now, there can be little doubt that the rate of production in this country, before the introduction of root crops, artificial grasses, and the improvement in the herds of horses, oxen, sheep, and pigs, was little if any more than one-twelfth of that which is at present obtained from the soil; and conversely it is certain that the whole population was regularly or occasionally occupied in agricultural pursuits. As measured by quantity, therefore, the cost of production was far greater in ancient or mediæval than in modern times; and similarly, the amount of the population must have been, it may be safely concluded, no more than an eighth of that which now inhabits England and Wales. Nor is this reasoning without its modern parallels. In the most fertile states of Western America, the rate of production is little more than from twelve to twenty bushels of wheat to the acre, the power of abundant export being derived from the large area of land available for cultivation, the ease and cheapness of transit, and the substitution of mechanical for manual labour. The increase in the rate of production and the diminution in the cost of production have not, therefore, it may be safely asserted, been derived from the necessity uniformly alleged in the ordinary theory of rent, that namely of increased expense incurred in the cultivation of inferior soils, but in the discovery and adaptation of forces in agricultural chemis-

try; in the study of practical physiology in the herds of animals, both of which means for cheapening the process have been developed to a remarkable degree; and in the application of mechanical force in aid or in substitution of human or manual labour.

The diminution in the cost of production in the supply of manufactured goods is still more notable; and the reader may be referred to Mr. Babbage's *Economy of Machinery and Manufacture* for information and illustration on this topic.

The question how far the cost of production is increased by the operation of trades' unions and the accompanying machinery of strikes, will be found below under the head TRADES' UNIONS. The reader may be referred to the same head for a statement of what appears to be the real incidence of such attempts to raise wages, as also to the articles COMBINATION, LABOUR, and WAGES.

Proedri (Gr. προέδροι). Certain Athenian officers chosen to superintend the proceedings in the two legislative assemblies; so called because they had the privilege of sitting in the front seats (προεδρία). The proedri of the senate were ten in number. [PRYTANES.] The proedri of the ecclesia were more in number, one being appointed from each tribe, which did not contain the prytanes for the time being. Their duties extended only to the one assembly of the people, a new set being elected each time; and one of their number was appointed EPISTATES or president. Their employment was to propose the subject of debate to the people, and to count the votes.

Proem (Gr. προοίμιον, *an opening*, from οἶμος, *a path*). A word sometimes used as synonymous with PREFACE or *introduction*. By the ancient Greeks it was used especially to denote a short hymn introductory to a longer poem.

Proemptosis (a word made up from Gr. πρό, *before*, ἐν, *in*, and πτῶσις, *a falling*). The term applied to the lunar equation or addition of a day to prevent the new moon happening too soon; this must be done every 330 years, and another day must be added every 2,400 years. The opposite term is *metemptosis*, which is used to signify the solar equation necessary to prevent the new moon from falling a day too late, or the suppression of the bissextile every 134 years.

Professor (Lat.). The recognised title, in all universities, of the public and authorised teachers in the various faculties. In the origin of those institutions the degrees conferred on students were, in fact, licenses to commence as public teachers; and the terms *master*, *doctor*, and *professor* seem to have been used indifferently. But as in process of time the great body of graduates ceased, in most universities, to have any concern in public instruction, a separate body of recognised teachers gradually arose; endowed in some instances with salaries, in others paid by fees. These were the professors. But in those universities in which collegiate foundations prevailed, as in Oxford and Cambridge, these officers fell into a secondary situation. The necessary business of instruction was transacted, and still continues to be so, by the functionaries of the several colleges. The professors therefore, and the instruction which they convey by lectures, have become only auxiliaries, instead of principals, and attendance on their lectures is in few cases compulsory. On the other hand, in universities destitute or nearly so of collegiate endowments (as those of Scotland, Germany, and others founded on the German model), the professors have become at once the governing body of the university, and the sole recognised functionaries for the purpose of education.

Profile (Fr. profil, Ital. profilo). In Architecture, the contour of the different parts of an elevation, whatever may be the style adopted.

PROFILE. In the Fine Arts, an outline of the principal parts of an object, free from all foreshortening, showing their real projections, indentations, &c.

PROFILE. In Fortification, a vertical section through a work, perpendicular to the face of the work.

Profit (Fr.; Ital. profitto, from Lat. profectus, *advantage*). In Political Economy, that rate of increase on capital with which the capitalist is so far satisfied as to constantly accumulate, either on the presumption that his capital will with moral certainty be repaid him in case he makes an advance to others, or on the conviction that his capital will be replaced in case he employs it for his own advantage. There is, therefore, no fundamental difference between the rate of interest and the rate of profit: the distinction lies only in the employment of the capital accumulated, for interest is always used to designate the profit on a loan, while profit is made to imply at once the recompense made for advances, and the addition made to capital employed by its possessor. It is, therefore, important to distinguish profit from wages, and to understand by wages not only payments made to labour, but all that part of a man's advantage from the employment of capital which is obtained by the fact that he devotes labour and skill to the occupation in which he is engaged, and by which (in case any risk attaches to his business) he secures himself such an increased remuneration as forms, so to speak, a species of insurance on his outlay; in other words, a capitalist must be paid for his trouble, as well as be rewarded for abstaining from spending his possessions on his personal enjoyment. Wages of labour in similar occupations tend to an equality; and, either consciously or unconsciously, everyone attempts to insure himself against risk. When, therefore, the labour is satisfied, and the risk is obviated, the remaining portion of the increase is profit; and as this remaining portion is on hypothesis secured to the capitalist as fully as the cost of the items which make up what is popularly called profit in business, it will not, and cannot be, more

than the rate of interest. Hence, when it is said that a small trader in a small town requires a large rate of profit on his transactions, while a great one is satisfied with less, no more is meant than that the wages of labour distributed over each sale, and perhaps the risks of his occupation, are necessarily larger, pro ratâ, than those of the trader whose business is more extensive, and thus it is that traders with large business can always offer goods to customers at lower rates than those whose occupations are circumscribed and whose market is narrow. The rate of interest on capital is the same, the remuneration of other elements is larger.

The *rate of profit* is the least sum which persons will accept as an inducement to accumulation. If the persons who possess property are thrifty and averse to spending, they will be, and constantly are, satisfied with low rates of profit. The Dutch were thus satisfied, though the low rate which they accepted was forced upon their trade by themselves, in consequence of their foolishly endeavouring to maintain high prices by checking or regulating supplies. This fact was overlooked by Adam Smith, who ascribed the low rate of profit prevailing in Holland before the close of the eighteenth century, to the heavy taxation to which the country was subject. But taxation may be heavy, and general profits high, or taxation may be low and general profits low, for the rate of profit is not necessarily connected with taxation at all, since taxation need not do more than curtail the power of enjoyment possessed by individuals. On the contrary, if the habits of society in any community are such as to make them indisposed towards saving when the rate of profit is materially lowered, accumulations will cease, or, what is more frequent, capital will be destroyed by investment in undertakings which are ultimately unproductive or scantily profitable. In short, it is hardly necessary to say that there are two sets of economical phenomena which are particularly liable to the stimulus of inconsiderate investment; that, namely, in which the rate of profit is apparently high, and that in which the rate of interest is temporarily very low.

Adam Smith held that the cause which led to a diminution in the rate of profit was the competition of capitals. We have seen above that he also considered it might be the effect of increased taxation, and have adverted to what appears to have been the real cause of the low rate to which he refers as a fact in the history of Dutch trade and finance. But, unfortunately, when he says that a competition of capitals lowers profit, he does not inform us of the way in which this result ensues. It cannot be by a general lowering of prices, because this would mean that everyone got more for less money, and so no one would be the worse. Nor can it mean that it occurs because a competition in one branch of business lowers what are called the profits of the business by lowering the price of the article consumed, since no one has recognised more clearly than Smith has, that there is, all other things being equal, a tendency to equal profit in all callings. It remains, then, that the competition of capitals lowers profits by raising wages. This appears to be the case in all avocations but that of agriculture, where a low rate of profit may prevail in consequence of the competition of farmers for the occupation of the soil, the price of labour being uniform, and the increased rent for the license of cultivation becoming the advantage of the landlord. Of course this specialty will not remain as a permanent characteristic of the demand for land capable of cultivation, since the competition of capitals will tend ultimately, other things being equal, to equal rates of profit in agriculture and commerce. But if capitals lower rates of profit by competition, it must needs be by the competition for employment; and as the employment of capital is the maintenance of labour, the reduction of the rate will imply, as a consequence from large accumulations of capital, a large payment to labour for services. In other words, capital is working investment, and the only form which the investment can really take, whatever may be the apparent direction, is in the maintenance of labour. If the capital be very large, the only means in which it can be employed is in the enlargement of wages. It need hardly be said that this competition may not lower prices; it may in effect, by the demand for the materials of production, considerably raise them in certain directions.

The direction which an accumulation of capital considerably in excess of the ordinary or general requirements of an existing community may take, will be either that of increased labour on the soil, or increased production for foreign trade. But it does not seem absolutely necessary, in order that larger products should be obtained from the soil, that lands hitherto not susceptible of cultivation, or not up to this time cultivated profitably, should be occupied and tilled. This will not be necessary till all the capital which can be employed is devoted to the better cultivation of areas already cultivated, but cultivated imperfectly. And this, in fact, is what has happened historically in this country. It is probable that in the more settled parts of England—excluding, for instance, the Scotch and Welsh marshes, as much land was under the plough five hundred years ago as at present. We may certainly argue hypothetically, from the case of all possible capital being applied to areas at present cultivated, that the practice of agricultural skill has by no means reached the limit of productiveness, since it certainly has not absorbed all the capital with which it may be supplied. By far the most powerful means, however, by which the reduction in the rate of profit may be averted, lies in the increase of production for foreign trade; and this has been the means by which the vast accumulations of capital in this country, and to some extent in other countries

also, have been made, and are employed without any notable reduction in the rate of profit or interest, but, on the contrary, are accompanied by certain phenomena which indicate a rise in the rate.

Political economists are apt, in interpreting the phenomena of wealth, to ignore, in some degree at least, the fact that the reciprocal relations of communities are rapidly modifying the conclusions which have been accepted from the various restrictions which the policy or fears of administrations have laid upon international intercourse. In fact, the inhabitants of civilised communities are getting more and more into the condition of members of the same economical state, denser populations representing towns and manufacturing districts, scantier ones the regions where agriculture prevails. From this point of view, the emigration of settlers is attended, only on a larger scale, by the same phenomena as the immigration into towns, and does not so much represent the relief of a redundant population, as the creation of facilities for the cheap production of food, which shall be exchanged against the manufacture of the more densely inhabited regions. In this way, the customs duties collected on foreign goods correspond to the octroi which is levied on consumable articles in towns; and the creation or improvement in the means of transit from country to country is analogous to the act of making a railway from a town to a rural district, between which localities there has hitherto been either imperfect communication or no communication at all. Just, too, as the produce of country districts could not be purchased, unless a town supplied commodities of its own manufacture or commodities imported by its labour in a carrying trade, so no intercourse will take place with distant countries except on the terms of mutual advantage. Now, the more widely this intercourse is extended, the more fully communities understand that they have mutual and inseparable interests of the very highest significance, and see that differences tending to war, and the cessation of intercourse between nations, vary only in degree from the folly and ferocity of civil war, the more distinctly public opinion is led to the true interpretation of national jealousies and narrow patriotism, as being a mask for the aggrandisement of administrative vanity, or for the satisfaction of personal spleen, at the expense of the general community; the more certainly all the speculations of political economists, as to the mininum rate of profit, the effect of taxation on public resources, the possible exhaustion of fertile soils, and the enhanced cost of cultivating inferior ones, become practically unimportant, because their contingency is made so exceedingly remote, and will have only a theoretical value, never to be of immediate interest except as consequent on the ultimate overcrowding of the human race on the whole surface of the earth. Up to this time, on the hypothesis of a larger and more complete understanding of what really constitutes the friendly intercourse of nations, the occurrence of a minimum rate of profit will be indefinitely postponed by investment in what are called indeed foreign undertakings, but which are in reality, when the undertaking is of an industrial character, means for cheapening articles sold in the home market; the process by which all fertile soils employed for raising food are exhausted, will in all probability be extended into a geological period; the effect of taxation (unless indeed, as is rarely the case, it be levied for industrial purposes) will be seen to be the destruction of capital, and the creation of an order of persons unfitted for industrial pursuits; and the wisdom of administrations will be directed towards effecting a closer unity and larger interdependence of all societies composing the civilised world, instead of being, as is commonly the case at present, an alternation of suspicion, timidity, military aggrandisement, and economical loss.

It is in consequence of the partial developement of these wiser and happier views as to the intercourse of nations, that the predictions of many economists have been falsified by events. The land of this country has not increased a square mile in the last five hundred years, it has probably decreased by the abrasion of the sea; the agricultural produce has, as we have elsewhere stated, increased twelve times, the manufacturing industry fifty-fold during the last two hundred years. But the rate of profit, as measured by the rate of interest, has not varied notably for the last hundred and fifty years, i. e. since the time that legal interest was fixed by the statute of Anne at five per cent. This uniformity is to be assigned partly to the enormous developement of the internal resources possessed by the country, and as much to the foreign trade developed by it; but that foreign trade has been rendered possible only by the growth of wealth among other nations, by the increase of their powers of production and purchase, and, as is attested by facts, by the rate of profit being sufficient not only to stimulate accumulation, but to develope those faculties of observation and research which have issued in such singular and prodigious discoveries in the materials and the powers of nature.

It will be seen that, in the account given of profit, the word has been treated as identical with interest on advances, the sole difference discoverable in the two terms consisting in the fact that interest is understood to mean the payment made for loans, profit the advantage derived from the employment of capital by its owner. There is, it appears, no reason for recognising any other difference in the two terms, any more than there is for distinguishing that portion of the produce of the soil which is paid as rent to a landlord, and that which is retained by the cultivator in excess of the receipts of the tenant farmer, when such a cultivator happens to be also the owner of the

soil. Commonly, however, just as rent is confounded with interest on capital and wages of labour when the same person is the recipient of all these, so profit is confounded with wages when the same individual is at once capitalist and labourer. There would be, indeed, no practical evil in such an error, but only a logical indistinctness, were it not that in this confusion of wages and profit a different criticism were customarily applied to different individuals or different classes. It will not be difficult to discover instances of such a confusion and such a criticism.

A combination to raise profits, if profit be understood to mean the interest on capital, or, as Adam Smith calls it, the profits on stock, will be wholly nugatory, just as all legal regulations affecting to limit rates of interest have been invariably inoperative and illusory. But a combination to raise wages under the name of profits is not only possible, but general. Where the use of the combination is adopted by the worker, for wages paid by a capitalist, the mechanism is open, and we call the association of labourers a trades' union; but where the body of capitalists unite to maintain prices, or to fix a standard below which professional etiquette will not permit a fee to be taken, the mechanism is secret, and the real significance is obscure. But in effect trade and professional regulations are of exactly the same nature as the combinations of workmen, assume the same line of defence, are open to the same regulation, and are virtually unions for the increase of wages, however much they may affect to be attempts to secure uniform rates of profit. In short, although competition will be found to determine interest, rent, and insurance, it will be found, on a careful examination of facts, to have only a limited operation in determining the rate of wages. Everyone can understand what is the meaning of the more violent attempts to increase wages by a monopoly, by a trades' union, or by legislative enactments which give one of two contracting parties a power to fix prices, by refusing the same discretion to the others; but there are many other invasions of the natural freedom of economical action, which would be justly interpreted by a sound and scientific exposition of the principles on which the mutual services of mankind should be appraised and exchanged. Among these none are more frequent than combinations to raise wages, under the name of profits, and few have done more to hinder the mass of consumers from receiving all the benefits of fiscal reform and free trade. [TAXATION; WAGES.]

Prognosis (Gr. from πρό, and γνῶσις, *knowledge*). An opinion respecting the progress and termination of a disease.

Programme (Fr.; Gr. πρόγραμμα). An old university term, signifying an outline of the speeches or orations to be delivered on a particular occasion; but now applied in a more extended sense to the outline of any entertainment or public ceremony.

Progress (Lat. progressus, *a going forward*). The state journeys of royal personages were called by this name in old English etiquette. In the reigns of Elizabeth and James they were frequent, and somewhat costly to the wealthier subjects, inasmuch as they were usually honoured with the onerous privilege of affording hospitality to royalty. The *progresses* of Queen Elizabeth form the subject of a work by Mr. Nicholl. Perhaps the most celebrated progress in English history is that of James I. from Scotland to London on his accession.

Progression (Lat. progressio). In Arithmetic and Algebra, this term is synonymous with *series*. [ARITHMETICAL PROGRESSION; GEOMETRICAL PROGRESSION; HARMONIC PROGRESSION.]

Prohibition (Lat. prohibitio, *a hindering*). In Law, a writ to forbid any court from proceeding in a cause then depending, on suggestion that the cause does not properly belong to that court. In modern times, the writ of prohibition is chiefly used where parties have been impleaded before the ecclesiastical courts. It issues properly out of the Court of Queen's Bench; but it may also be had in some cases out of the Chancery, Common Pleas, or Exchequer. It is the proper remedy where the court against which it is sued has exceeded its jurisdiction in taking cognisance of matters not properly belonging to it. It is granted on motion; but if the question of jurisdiction be doubtful, the court directs the party suing the writ to *declare in prohibition*, i. e. to bring an action against the other party, praying that a writ of prohibition may issue, and gives judgment that the writ do or do not issue, as justice may require.

Projectile (Lat. projicio, *I throw forward*). In Gunnery, a body designed to be projected by the force of gunpowder.

It was shown in the article GUNNERY that the resistance of the air materially retards a projectile in its flight, and that elongated projectiles are less retarded than spherical ones of the same weight. The retardation of a projectile is also greatly influenced by the form of its head, and to some extent by that of its hind part. Newton, in his *Principia*, gives a form of body which would, in passing through a fluid, experience less resistance than any other (fig. 1); and Piobert proposes the form represented in fig. 2, in length five times its greatest diameter, and with its largest section

Fig. 1.

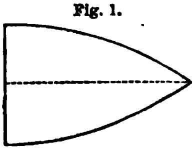
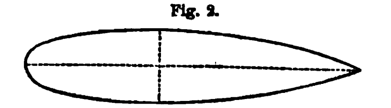


Fig. 2.



placed at two-fifths of the length of the projectile from its base. This form is very nearly

followed by Mr. Whitworth in some of his projectiles. In the last century, Dr. Hutton and Borda respectively carried on experiments upon bodies of different forms, moving with low velocities; and from Borda's experiments it appeared that the ogival form of head experienced the least resistance. A recent experiment, made under direction of the Ordnance Select Committee, to determine the relative retardations of elongated projectiles of equal weight (average 41 lb.), having similar bases, but differently formed heads, and fired at nearly equal high velocities, gave the following results:—

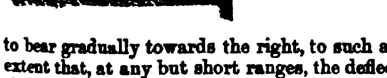
Form of projectile	*Loss of velocity in 460 yards* ft. per second
Cylindro-ogival	70
Cylindro-conoidal	98
Cylindro-parabolic	111
Cylindro-hemispherical	112
Cylindro-conical	117
Cylindrical or flat-headed . . .	170

The ogival form of head was less retarded than any other, and the conoidal head, used in our service, was next in the scale. The flat-headed projectile, as might be expected, experienced very great resistance.

The form of a projectile also affects its flight as regards deviation from the line of fire. When a round shot is fired from a smooth-bored gun, its deviation is uncertain, and depends upon the rotation which it has received, and which varies by reason of certain varying causes. Windage is the first and great cause of irregularity in flight; other causes of deviation, such as imperfect form, roughness, and want of homogeneity in a shot, will not be entered upon here, as they should be overcome by improving manufacture.

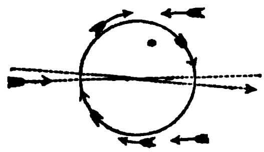
By reason of windage, when a shot is propelled, it bounds and rebounds along the bore, and finally leaves the muzzle in an accidental direction, and with a rotatory motion depending chiefly on the position of its last impact against the bore. A shot, the last impact of which is against the right side of the bore, will tend at first towards the left; but will have a rotation from left to right (fig. 3), which will cause it

Fig. 3.



to bear gradually towards the right, to such an extent that, at any but short ranges, the deflection will be to the right of the line of fire. The probable reason of this, as shown by Robins, is, that as the air in front of the ball is greatly condensed, its friction offers great resistance to the ball, behind which there is almost a vacuum, and therefore no counterbalancing force; hence the ball will tend to deflect in the opposite direction to that at first given to it. According to Magnus, if a ball leaves a gun, its fore part rotating on a vertical axis from left to right, it causes to rotate with it a portion of air; this is opposed to the resisting atmosphere on the left side, but acts with it on the right side (fig. 4). There will therefore be greater

Fig. 4.

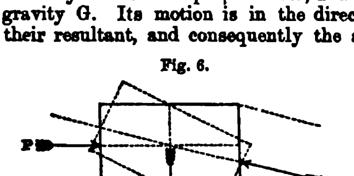


pressure on the left side than on the right, and so the ball will deflect to the right. With any other direction of rotation there will be corresponding deviation; in one case only will there be none, viz. when the ball rotates on an axis parallel to the axis of the bore, or coincident with the line of fire.

To give the projectile such a rotation is the object of rifling a gun, and the various methods of accomplishing this object are treated of in the article RIFLED GUNS. Elongated projectiles, the advantages of which have been noticed in the article GUNNERY, can be successfully fired from rifled guns, although they cannot be advantageously used with smooth-bored pieces, because they turn over during flight.

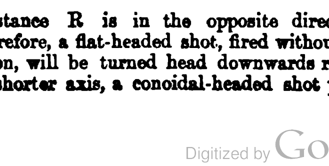
If to a flat-headed body, suspended horizontally from its centre of gravity, a pressure be applied before and below such centre of gravity, the head will thereby be depressed. If a force be similarly applied to a conoidal-headed body, its head will be raised. This is capable of easy proof either mathematically or by experiment. Now, the resistance of the air always does so press on the head of an elongated shot during flight, as shown in figs. 5 and 6. The shot is

Fig. 5.



acted on by the force of propulsion P, and that of gravity G. Its motion is in the direction of their resultant, and consequently the air's

Fig. 6.



resistance R is in the opposite direction. Therefore, a flat-headed shot, fired without rotation, will be turned head downwards round its shorter axis, a conoidal-headed shot point

upwards. But the imparting a rotatory motion to the projectile round its longer axis gives stability to that axis, and prevents the projectile from turning over.

The elongated projectile fired from a rifled gun is, however, in practice found to deviate from the line of fire to an extent more or less constant, and either to right or left according to the shape of the head, and the direction of rotation of the projectile. A conoidal-headed shot, fired with a right-handed rotation (i.e. a rotation from left to right of a spectator looking from behind the gun), will always deviate to the right; a flat-headed shot, with similar rotation, to the left. If the rotation is reversed, opposite results will ensue. An explanation of this phenomenon would extend beyond the limits of this article, but it may be briefly stated thus; take, for instance, the service cylindro-conoidal shot with right-handed rotation, as from the Armstrong gun: the resistance of the air will cause its point to be deflected to the right, and this resistance then acts obliquely on the whole projectile, and so deflects it to the right. This constant deviation is called by artillerists *derivation*, a word adopted from the French, and it must be allowed for in laying the gun. [SIGHTING ORDNANCE.]

The velocity of rotation, which an elongated projectile requires to keep its rotation stable round its longer axis, will depend upon the initial velocity, form, and density of the shot, and the position of its centre of gravity. As the initial velocity increases, the resistance of the air, tending to upset the projectile, becomes greater. Long projectiles are more easily turned over than short ones of equal weight, for the upsetting force acts with longer leverage. The same applies to a shot with its centre of gravity far back. Flat-headed projectiles are more easily turned over, for the air acts directly on their heads, instead of gliding by as with a pointed or rounded head. The less the density of a shot in proportion to size, the more rapidly will the air's resistance decrease the shot's velocity of rotation.

The projectile, therefore, must be made according to these laws, or else, to meet any of these cases, a very high velocity of rotation must be given to it, and this is objectionable, as causing (1) a very great strain on the metal of the gun, (2) extreme deflection upon grazing, and (3) too great a lateral spread of the pieces of shell.

It now remains to notice the best form and material of projectile for the various purposes of war. And, first, as regards the great problem of the modern science of artillery, the penetration of iron armour-plate. The materials used in the manufacture of projectiles for this purpose have been cast iron, wrought iron, and steel. Service cast-iron shot, cast in sand in the usual manner, are found to be very inefficient, breaking up easily on impact, though penetration has been obtained by them. The heaviest cast-iron shot yet fired in this country were those from the Horsfall gun; one weighing 279 lb. with an initial velocity of 1,631 feet, completely penetrated the 'Warrior' target at 200 yards, doing great damage; but at 800 yards, similar shot, though having a velocity on striking of 1,300 feet, failed to penetrate. A fifteen-inch cored cast-iron shot, weighing 430 lb., fired with 35 lb. of powder from the United States' monitor 'Weehawken,' shattered, at about 300 yards' range, the armour of the Confederate iron-clad 'Atlanta,' doing frightful damage; but an eleven-inch ball of 169 lb., with 20 lb. of powder, did not break the same armour. The 'Atlanta's' armour, however, was composed only of laminated plates of the aggregate thickness of 4½ inches, very inferior to a solid plate of the same thickness, and was backed by yellow pine, a wood very inferior to teak. Good results have been obtained from some chilled cast-iron shot proposed by Major Palliser; and if by further experiments we can obtain shot of this nature, possessing hardness enough for penetration, without too much toughness, they will be very valuable for use against iron-clads; for we shall obtain the advantage of their breaking into fragments after penetrating, besides saving much expense.

Wrought-iron shot have been occasionally tried. They never break up, but are much *set-up* or altered in form after impact. Experiments have all gone to prove that wrought iron, though somewhat superior to ordinary cast iron, is far inferior to steel, and is not to be recommended as a material for projectiles to be used against iron plates.

Undoubtedly by far the most damaging projectiles yet tried against armour-plated vessels are steel shells, and to Mr. Whitworth belongs the honour of first proving that a shell could be sent through an iron-plated ship of war. His shell and that of Sir W. Armstrong differ considerably; the former is solid at the head, and open at the rear to receive the bursting charge, being afterwards closed by a screwed-in steel cup; the latter is open in front, and a hollow cast-iron head is screwed on, which breaks up on impact. The latter form seems the best, as allowing the force of the bursting charge to act forwards instead of backwards. The terrible effects of the 612 lb. steel shell at 1,000 yards on the 'Warrior' target were greater than any yet seen. In fact, it is now established that the 'Warrior' target can be easily pierced at 2,000 yards by a shell containing a bursting charge of 24 lb. of powder.

During some experiments lately made in Russia, some steel shells, manufactured by Krupp, of Essen in Prussia, penetrated a target covered with 4½-inch armour-plates. These projectiles were made of the very best and most costly description of steel.

As regards form, elongated projectiles have far greater power of penetration than spherical shot. Their comparative effects may be thus summed up: the elongated projectile striking a plate with the same momentum as a spherical

one, will penetrate deeper than the latter, for, although the force of the blow given by each projectile will be the same, there will be a greater amount of resistance due to the greater diameter of the spherical projectile; consequently its penetration is less than that of the elongated projectile, but the force of the blow is more spread, and the shattering effect is greater. Experiments also led the Committee on Iron to report that conical-ended shot are superior in accuracy and range to flat-ended projectiles, and that, except perhaps for oblique firing, they are also superior for penetration. The following is the evidence of Sir W. Armstrong: 'I do not see how you can produce with steel round shot an effect comparable to the effect which can be obtained with cylindrical rifled shot. With respect to employing steel spherical shell, capable of penetrating iron plates, I consider it out of the question. It is only by means of the elongated form of the projectile that we can produce a steel shell capable of piercing an iron plate, and it is due to the principle of rifling that the elongated form can be adopted.'

The experiments conducted against the 'Hercules' target, which has a total thickness of 4 ft. 10½ in., the outside plates being respectively 9 in. and 8 in. thick, have shown that a ship may be constructed proof against even a steel shot of 580 lbs. weight, striking with a velocity of 1,310 feet per second. The Americans have turret ships carrying 14 in. of armour; and such vessels we must in any future contest expect to encounter.

The following table, extracted from Major Owen's *Lectures on Artillery*, gives the effects produced on the same description of target (the 'Warrior') by various projectiles, fired with different charges, and at several ranges.

Gun			Projectile		Charge	Velocity		Range	Effect on Target
Nature	Weight	Calibre	Nature	Weight		Initial	Final		
	cwt.	in.	*Cast-iron :—*	lb.	lb.	ft.	ft.	yds.	
S.B. 68 pr.	95	8	Spherical shot	66¼	16	1579	1567	200	Depth of indent 2".
Rifled B.L. 110-pr. (A.)	81	7	Elongated shot	111	14	..	1121	„	„ „ 1·6".
Rifled Ditto. „	„	„	„ „	200	10	765	..	„	Indent too small to be measured.
Rifled M.L. 120-pr. „			„ „	140	20	..	..	„	Depth of indent 3·1".
	tons								
S.B. Horsfall	24	13	Spherical „	279½	74½	1650	..	„	*Through target*; hole in plate 28"×25", and in skin 5 ft. square.
Ditto.	„	„	„ „	284	„	„	1299	800	Hole in plate 2'×1' 11"; penetrated to 12".
	cwt.		*Chilled cast-iron :—*						
Rifled M.L. 7" (A.)	134	7	Elongated R.H. shot	104	25	1516	..	200	Hole in plate 8·5"×7·5"; penetrated to a depth of 9".
Rifled Ditto	„	„	„ E.H. „	„	„	1558	..	„	*Through target*; hole in plate 8"×7·5", hole in skin 18"×14".
			Steel :—						
R. 70-pr. (W.)	76	5	Elongated F.H. „	71	12	1275	..	„	Through plate, and 3" into backing.
S.B. 68-pr.	95	8	Spherical „	74	16	..	..	„	Through plate, and 4½" into backing.
S.B. 100 pr. (A.)	125	9	„ „	105	25	1653	..	„	Hole in plate 9"×9", depth to shot 6·5", skin cracked.
R.M.L. 7-in. (A.)	134	7	Elongated R.H. „	104	25	1625	..	„	*Through target*; hole in plate 8"×7·5", hole in skin 18"×12".
R.M.L. 150-pr. (W.)*	148¾	6·4	„ F.H. shell	130	25	..	1268	600	*Through target*; hole in plate 8·5"×7·5", and in skin 15", fragments inside target.
Ditto	„	„	„ F.H. shot	130	27	..	1204	800	*Through target*; hole in plate 8"×8·3".
Ditto	„	„	„ F.H. shell	151	27	..	1175	„	*Through target*: hole in plate 7·5", and in skin 10", fragments inside target.
	tons								
R. 600-pr. (A.)	22	13·3	„ R.H. cast-iron head shell	610	70	..	1143	970	*Through target*; hole in plate 24"×21", and in skin 30"×24"; target shattered.
Ditto	„	„	Ditto ditto	„	„	..	940	2000	*Through target*; hole in plate 16"×15½", and in skin 4'×2'3"; one plate blown off; fragments inside target.

* At first called 120-pounder.

S.B. smooth bored.
E.H. elliptical head.
F.H. flat head.
R.H. round head.

R. rifled.
(A.) Armstrong.
(W.) Whitworth.

		lb.
Bursting charge of Whitworth's 130 lb. shell		3½
„ „ „ 151 lb.	„	5
„ „ Armstrong's 610 lb.	„	24

For breaching masonry, whether protected by iron plates or unprotected, heavy solid shot must be used, followed by shells with large bursting charges. Ricochet fire is now so entirely abandoned for shell fire, that the elongated shell holding a large bursting charge seems the best projectile for other siege purposes.

In the field, Sir W. Armstrong's segment shell has with us superseded all other projectiles, being capable of use either as shot, shrapnel shell, common shell or case, though as shot it is no better than the common solid shot and much more costly, while it is not thoroughly efficient as either common shell or case, and a special case shot, invented by Lieut. Reeves, R.A., is about to be introduced on this account; and it has lately been decided that another form of shrapnel shell (Boxer's) is far superior in destructive effect.

Finally, wherever it is practicable, the gun should be made for the projectile, and not the projectile for the gun, and both should be of as simple construction as possible. It is necessary in the first place to determine the conditions of velocity, form of shot, &c., requisite to obtain accuracy, range, and penetration; also the shape of the projectile best adapted to the destructive purpose for which it is intended; secondly, to contrive a gun which shall give a certain projectile the necessary initial velocity and velocity of rotation, and which shall combine excellence and simplicity of construction with the requisite weight, strength, and durability.

For further information, see GUN; GUNNERY; RIFLED GUNS; &c.; and the following works: Major Owen's *Lectures on Artillery*, 4th edit.; Owen's *Motion of Projectiles*; Holley *On Ordnance and Armour*; *Reports of the Committee on Iron Plates*, Bluebooks; Captain Harrison in *Royal Artillery Institution Proceedings*, vol. iv.; *Report of Armstrong and Whitworth Committee*; &c.

PROJECTILE. In Mechanics, a body which having had a motion in space impressed on it by the action of an external force, is abandoned by this force, and left to pursue its course. Thus, a stone thrown from the hand or a sling, an arrow shot from a bow, and a bullet discharged from a cannon, are projectiles while they continue in motion.

Projection (Lat. projectio, *a throwing forward*). In Astronomy, this term is employed when a star actually occulted by the moon appears to be projected on its disc. It is an optical illusion which frequently occurs.

Projection, Method of. A modern and very powerful method of investigating and generalising the properties of plane as well as of non-plane curves. In general any two curves traced on the same cone may be considered as projections one of the other. The vertex of the cone is called the point or *centre of projection*, and one, at least, of the curves is usually conceived to lie in a plane, the *plane of projection*. Each generator of the *projecting cone* is called a *projecting ray*.

The *graphic*, as distinguished from the *metrical* properties of *non-plane curves*, may be advantageously studied by means of their plane projections. To illustrate this, we may observe that: 1. The plane projection of a non-plane curve must be of the same order as the latter; for the number of intersections, with the projection of any right line, must necessarily be equal to the number of points in which the projecting plane of that right line meets the non-plane curve. 2. The *class* of the projection will be equal to the *rank* of the curve; in other words, to the *order* of its developable osculatrix [CURVE]; for the latter is equal to the number of tangents to the curve which meet any projecting ray, and therefore to the number of tangents to the projection which pass through the point where that ray intersects the plane of projection. 3. The number of *stationary tangents* (points of inflection) of the projection will be equal to the *class* of the curve; for the latter is equal to the number of osculating planes which pass through the centre of projection, and each such osculating and projecting plane contains two consecutive tangents of the curve, and therefore two *coincident consecutive tangents* of the projection. 4. To every *stationary point* on the curve corresponds a stationary point on the projection; for through such a stationary point pass three consecutive tangents, a property which is clearly projective. 5. The number of *double points* on the projection will indicate how many projecting rays meet the curve in two points, coincident or distinct; it will be equal, therefore, to the sum of the *real* and *apparent* double points of the curve, or, in other words, to the number of '*lines through two points*' which pass through a given point. [CURVE.] 6. Double tangents of the projection also arise from apparent as well as real double tangents of the curve, and their number merely indicates how many '*planes through two lines*' pass through an arbitrary point (the vertex). From the above analysis it will be easily understood how Plücker's equations, connecting the ordinary singularities of plane curves, may be generalised to suit the case of non-plane curves. Mr. Cayley has, in fact, done this in a paper published in the *Cam. and Dublin Math. Jour.* vol. v.

We proceed to notice some of the more important properties of *plane projections of plane curves*. It is obvious, from what has been already stated, that the ordinary singularities of such curves all reappear in their plane projections; these singularities are included in the so-called *projective properties* of figures. It should be here stated, however, that such properties are not exclusively *graphic*. Many *metrical* properties are also projective, and, what is most important, anharmonic ratios of points and lines are so. [ANHARMONIC RATIO.] Thus a pole and its polar with respect to any conic become by projection a pole and polar of another conic; for the polar A of any point a with respect to a conic Σ, is simply the locus of the harmonic conjugate of a with respect to the intersections with Σ of any transversal through a. This simple theorem is extremely rich in consequences; we cannot, however, dwell upon them, and must refer the reader to Poncelet's classic work on the *Propriétés Projectives des Figures*, or to the writings of Chasles, Steiner, Salmon, &c. We will merely add that many important theorems with respect to conics may be easily demonstrated by remembering that, with a proper choice of the centre and plane of projection, any conic may be projected into a circle, and at the same time any line in the plane of that conic into the line at infinity. If this be done with the above conic Σ and polar A, for instance, the projection of the pole a will manifestly be the centre of the circle into which Σ is projected. Further, two non-intersecting conics may always be projected into two circles, and if the former have double contact, the chord of contact being imaginary, the latter will be concentric.

We have still to mention the plane projections of figures obtained by assuming the centre of projection to be infinitely distant. In this case the projecting cone becomes a *projecting cylinder*. The projection is termed *orthographic* or *orthogonal* when the plane of projection is perpendicular to the generators of the projecting cylinder; in other cases it is called oblique. In descriptive geometry, for example, orthographic projections of objects upon a vertical and a horizontal plane are taken; whilst in Cartesian coordinates a figure

in space is determined by its orthographic projections on three rectangular coordinate planes. In orthographic projection, lines parallel to the plane of projection are not altered in length, others are shortened in the ratio of unity to the cosine of their inclination to the plane of projection. The area of the orthogonal projection of a figure is equal to that of the figure itself multiplied by the cosine of the inclination of its plane to that of projection. The orthogonal projection of a circle, inclined to the plane of projection, is always an ellipse whose centre is the projection of the circle's centre, whose major axis is equal to the diameter of the circle and parallel to the intersection of its plane with the plane of projection, and whose minor axis is of course equal to that diameter multiplied by the cosine of the inclination of the two planes.

A useful form of orthographic projection, suitable for the representation as well as for the investigation of geometrical figures whose principal lines, like those of a parallelopiped, are parallel to one of three mutually rectangular axes, was invented by Farish, and termed *isometrical*; since, the plane of projection being equally inclined to the three axes, all distances parallel to the latter are shortened in the same ratio, viz. that of $\sqrt{3} : \sqrt{2}$. The projections of the principal lines of the figure make an angle of 120° with each other. The projections of level lines, i.e. of lines parallel to the plane of projection, are of the same length as their originals, and are necessarily perpendicular to the projections of one set of principal lines and inclined at an angle of 30° to those of the other two sets. The lines of greatest slope on the principal planes are represented by lines parallel to the projections of one set of principal lines, and consequently inclined to those of the other two at an angle of 60°. Such lines are shortened by projection in the ratio of $\sqrt{3} : 1$. Every circle on a principal plane is projected into an ellipse with its major axis parallel to the projections of the lines of level and equal to the diameter of the circle, the ratio of its two axes being that of $\sqrt{3} : 1$.

Projection of the Sphere. On account of their importance in the construction of maps, charts, &c. we have reserved for a short separate notice the more important methods of projecting figures traced on the surface of a sphere.

1. *Orthographic Projection.*—The general character of this method having been already explained, it is only necessary to add that orthographic projections of the sphere are usually made either on the plane of the equator or on the plane of a meridian. When on the plane of the equator, the meridians are all represented by straight lines intersecting in the centre of the projection, and the parallels of latitude by circles whose radii are respectively equal to the cosines of the latitude. When the representation is on the plane of a meridian the other meridians are represented by ellipses, and the parallels of latitude by straight lines parallel to the diameter of the projection. The chief defect of orthographic projections of a hemisphere is, that near the circumference of the representation the figures are greatly crowded and distorted.

2. *Stereographic Projection.*—The plane of projection may here be that of any great circle; the centre of projection is then taken at one of its poles. Accordingly the spherical figure and its projection are *inverse* to one another [INVERSION]; hence all circles are projected either into straight lines or into other circles, and the angle between any two intersecting curves on the sphere is preserved unchanged in the projection. The first of these important properties was known to Hipparchus and Ptolemy, the former of whom invented the projection and gave it the name of *planisphere*. The second property was first demonstrated by Dr. Halley in the *Phil. Trans.* for 1696; an important consequence being that corresponding small portions of the spherical figure and its projection are *similar*.

3. *Gnomonic or Central Projection.*—In this projection, also described by Ptolemy, the eye is situated at the centre of the sphere, and the plane of projection is a plane which touches the sphere at any point assumed at pleasure. The point of contact is called the *principal point*; and the projections of all other points on the sphere are at the extremities of the tangents of the arcs intercepted between them and the principal point. As the tangents increase very rapidly when the arcs exceed 45°, and at 90° become infinite, the central projection cannot be adopted for a whole hemisphere.

A modification of this projection consists in taking the plane of one of the polar circles as the plane of projection. It is then called a *polar projection* of the sphere.

4. *Globular Projection.*—This projection was proposed by Lahire. The plane of any great circle being taken as the plane of projection, a point in its axis, *outside the sphere*, is assumed as the centre of projection. In order that the representation of the more distant hemisphere may be as little distorted as possible, the shortest distance from the eye to the sphere must have to the radius the ratio of the side to the diagonal of a square.

5. *Conical Projection.*—The centre of projection being still the centre of the sphere, the *surface* of projection is now a right cone which may either touch the sphere in a parallel of latitude or intersect it in two such parallels. The conical surface is ultimately supposed to be unfolded into a plane, when, manifestly, meridians will be represented by right lines converging to a point, and parallels of latitude by circular arcs around that point as centre.

6. *Cylindrical Projection.*—The centre of projection being the same as before, the surface of projection is here supposed to be a *cylinder* touching the sphere at the equator. When the cylinder is unfolded, meridians and parallels of latitude are each represented by parallel lines, the lines of longitude, corresponding to

successive degrees, being equidistant, and perpendicular to the lines of latitude whose distance apart increases rapidly with the latitude. MERCATOR'S PROJECTION may be considered as a modification of the present one, the *projecting rays* being curved instead of straight.

7. *Homolographic Projection.*—This, like Mercator's, is not a proper projection. It may be described as a representation of the sphere on the principle of the conservation of relative areas, in other words, so that the areas of any two portions of the map shall have the same ratio to each other, as the areas of the corresponding portions on the sphere. Flamsteed solved the problem approximately; Cauchy investigated it mathematically; and Babinet has, we hear, published maps constructed on the basis of Cauchy's calculations.

Projecture (Lat. projectura). In Architecture, the jutting or leaning outwards of the mouldings and other members of architecture beyond the face of a wall, column, pilaster, cornice, &c.

Prolapsus (Lat. part. of prolabor, *I fall forward*). A protrusion or falling down of a part of a viscus that is uncovered.

Prolate Spheroid. In Geometry, a spheroid produced by the revolution of an ellipse about its major axis; so called in opposition to the *oblate* spheroid, which is produced by the revolution of the ellipse about its minor axis. [SPHEROID.]

Prolegomena (Gr.). In Literature, preliminary or introductory observations or dissertations prefixed to any work.

Prolegs. In Entomology, the fleshy exarticulate, pediform, often retractile organs, which assist various larvæ in walking and other motions, but which disappear in the perfect insect.

Prolepsis (Gr. *an anticipation*). In Rhetoric, a figure by which the speaker anticipates and answers imaginary objections to the sentiments which he is urging.

Proletarian (Lat. proletarius). In the constitution attributed to Servius Tullius, Roman citizens who did not possess the amount of property requisite for admission into the lowest class were so called (as it is said from proles, *offspring*, because they had only their children to offer to the state). Hence, in modern political language, the name is frequently applied to the destitute portion of the population. [CAPITE CENSI.]

Prologue (Gr. πρόλογος). A piece in verse recited before the representation of a play, and serving as an introduction to it. [EPILOGUE.]

Prolonge (Fr.). In Artillery, a rope used to drag a gun-carriage without the limber, when it is required to retire firing through a street of a village, or any narrow defile.

Prolusion (Lat. prolusio). A classical word which has been adopted in a rather general sense by authors unwilling to claim for their own productions a more ambitious designation. Thus used, the term denotes an essay or preparatory exercise, in which the writer tries his strength, or throws out some preliminary remarks on a subject which he intends to treat more profoundly. The early and fugitive pieces of some poets (as the *Culex* and others attributed to Virgil) have been termed, by critics, their *prolusions*.

Prometheans. A term applied to paper matches enclosing small glass tubes containing concentrated sulphuric acid, and surrounded with an inflammable mixture, which becomes ignited on sufficient pressure being applied to break the glass tube.

Prometheus (Gr.). In the Hesiodic *Theogony*, a son of the Titan Iapetus; but according to Æschylus, a son of Themis (*law*). It is impossible to harmonise the legends of his life and acts. In the tale of Æschylus, Prometheus, the *fore-thinker* (as his brother Epimetheus is one who takes counsel after the event), feels compassion for the misery of men, who know neither how to cook food or to build houses. Having stolen fire from heaven, he imparts the gift to mortals, who are now taught by him the arts necessary to civilise and to sweeten life. This myth, it is obvious, conveys an idea altogether opposed to that of the Hesiodic Ages, in which men are represented as beginning with a golden existence and gradually degenerating. The favour shown to men by Prometheus rouses the anger of ZEUS, who forgets the aid received from him in the war against Cronos. Zeus bids Hermes to chain Prometheus on the rocks of Caucasus, where an eagle perpetually gnaws his liver. While Prometheus is there exposed, Io in her wandering comes to him, and learns that from her is to spring his future deliverer Heracles. But the wrath of Zeus was not yet satiated. Prometheus had warned his brother Epimetheus to receive no gift from the gods; but Zeus ordered HEPHÆSTUS to mould a virgin who should receive some grace from each of the gods. Thus invested with all the charms that could attract men, PANDORA was presented by Athena to Epimetheus, who received her into his house, in which lay the cask containing under its closed lid all the evils that may afflict mankind. Pandora raised the cover, and all the evils flew out. Frightened at the result, Pandora replaced the lid and made Hope a prisoner in the cask, and thus deprived men of all alleviation of their sufferings.

It has, indeed, been contended that the shutting-up of Hope within the cask was an act of mercy, and that, as the escape of Hope would have left men to utter despair, Pandora was bidden by Zeus to replace the lid; but the genuineness of the line which contains this command is very doubtful; while the whole legend represents Zeus as inexorably hostile to men, and as unlikely to interfere in their behalf. In Mr. Grote's opinion, the point is one which does not admit of question. 'Pandora,' he says, 'does not, in Hesiod, *bring with her* the cask. . . The case is analogous to that of the closed bag of unfavourable winds which Æolus gives into the hands of Odysseus, and which the guilty companions of the latter force

open, to the entire ruin of his hopes. . . . The diseases and evils are inoperative so long as they remain shut up in the cask; the same mischief-making influence which lets them out to their calamitous work, takes care that Hope shall still continue a powerless prisoner in the inside.' (*History of Greece*, part i. ch. iii.)

In some versions of the myth Athena is the accomplice of Prometheus in the theft of fire, and his tortures on Caucasus are a punishment for his unlawful love which is returned by the virgin child of Zeus. [MINERVA.] In other legends Prometheus is called the father of DEUCALION, whom he warns to build the ark which saves from the flood the scanty remnant of mankind. After the flood, Prometheus made men from mud, and the winds breathed life into them.

Another cause for the feud between Zeus and Prometheus is given in an institutional legend which accounts for the portion of each sacrifice assigned to the gods. Prometheus, warning men that their substance would be wasted if they consumed the victims with fire, slew an ox, and, dividing the body, placed the entrails and flesh under the skin, and the bones under the fat. Zeus, being bidden to lay his hand on the portion which he desired for himself, took the fat, and his rage was kindled when he found that henceforth the bones were to be his share, while the flesh belonged to men. This version represents Zeus as taking away in consequence the gift of fire, with which men had already been made familiar.

In the Hindu traditions, the Pramantha is the wooden churn used for kindling fire with dried pieces of wood.

Promissory Note. A note or writing by which one or more persons promise to pay a certain specified sum of money at a certain date. Such documents, if drawn on proper stamps, are legal negotiable instruments enjoying the same privileges as bills. No negotiable or transferable bill or note (not being a draft on a banker) can be lawfully drawn or made for any sum under 20*s*.

Promontory (Lat. promontorium, from mons, *a mountain*). In Geography, a point of land, whether high or low, projecting into the sea. [CAPE.]

Promptuary (Lat. promptuarium, *a storehouse*). In Literature, a title sometimes given to works of the class of summaries, handbooks, and the like, in which subjects are so arranged as to be *prompt*, or ready for use.

Promulgation (Lat. promulgatio). In Jurisprudence (though not strictly in English Law), the name commonly given to the acts of publication of laws and other instruments from the date of which (unless otherwise specially provided therein) they become valid. Thus, in France, a law becomes executable as soon as it is inserted in the printed *Bulletin des Lois*.

Promuscis (Lat.). The name of the suctorious organ of the Hemipterous insects, formed by the union of the two jaws (*maxillæ*) to the lower lip, which they embrace; thus forming a jointed organ, containing four long capillary lancets and a short tongue.

Pronaos (Gr.). In Ancient Architecture, the front porch of a temple. This corresponded with the NARTHEX of the early Christians. [NAOS.]

Pronator Muscles (Lat. prono, *I make prone*). Those which are used in turning the palm of the hand downwards.

Pronoun (Lat. pronomen). In Grammar, a part of speech used in the stead of nouns, to avoid needless or inconvenient specification. Pronouns are divided into *substantive* or *personal*, and *adjective*; the latter including *possessive, demonstrative, relative, indefinite*, and *interrogative* pronouns.

Proof (Fr. épreuve, from Lat. probo, *I try* or *test*). In Engraving, an impression taken from an engraving to prove the state of it during the progress of executing it; also one taken before the letters are engraved on the plate.

PROOF. In Printing, an impression of a sheet of a work on which the errors and mistakes are marked for the purpose of being corrected. Proofs are: *first proof*, which is the impression taken with all the errors of workmanship. After this it is read by the copy, and the errors having been corrected, another impression is printed with more care, to send to the author; this is termed a *clean proof*. On it he makes his corrections and alterations: when those are altered in the types, another proof is printed (on the paper proposed for printing the work, so as to settle the margin), and read over carefully, previously to the whole number being printed off; this is called the *press proof*.

PROOF. [EVIDENCE; HISTORICAL CREDIBILITY.]

Proof of Ordnance. All guns are proved at Woolwich before being issued for service. The tests are instrumental, water (for muzzle-loading guns only), and fire proof. Any gun failing to reach the standard of any of the tests is returned for alteration or rejected.

Proof Spirit. A mixture of equal weights of absolute alcohol and water; the specific gravity of such a mixture is 0·917; but that of the proof spirit of commerce is 0·920 at 60°. The term *proof* appears to be derived from the gunpowder test. Spirit was poured over gunpowder and the vapour inflamed: if it fired the gunpowder, it was over-proof; if it burnt without igniting the powder, owing to the residuary water rendering the powder damp, it was said to be under-proof. The weakest spirit capable of firing gunpowder was the proof spirit of pharmacy, specific gravity 0·920. [ALCOHOL; HYDROMETER.]

Propædeutics (Gr. προπαιδεύω, *I instruct beforehand*). A term used by German writers to signify the preliminary learning connected with any art or science.

Propaganda (Lat.). The name given to an association, or, as it is termed, the congregation *De propagandâ Fide*, established at Rome by Gregory XV. in 1622, for diffusing a know-

ledge of Catholic or Papal Christianity throughout the world. It is a committee of cardinals and special agents of the pope, under whose presidency it meets every week. Its duties are, the superintendence and assistance of missionaries in all parts of the globe, the maintenance of recent converts, the publication of religious works in foreign languages, &c. Derived from this celebrated society, the name *propaganda* is applied in modern political language as a term of reproach to secret associations for the spread of opinions and principles which are viewed by most governments with horror and aversion.

Propagation of the Gospel in Foreign Parts, Society for the. [SOCIETIES.]

Propagation of Plants. The greater number of plants are propagated naturally by means of seeds. Many plants, however, increase by extending over the surface, on which they take root by the production of runners or lateral shoots, which spread along the surface, and root at the joints or buds, from which they send up new plants; by the developement of suckers or side shoots from the roots; and by various other natural means.

Artificially, plants are propagated by seed, by runners, suckers, offsets, dividing the tubers, layers, cuttings, grafting, budding, inarching, &c. Seeds are gathered when mature, and sown on recently stirred soil, and covered to different depths, according to the size of the seed, the nature of the soil and situation, and other circumstances. The plants formed by runners are separated from the parent plant by cutting through the runner, and removing the young plant, in order to place it elsewhere. Suckers, slips, or side shoots from the roots, are separated from the parent plant by being slipped down, or cut off, so as to carry with them a portion of fibrous roots; and they are afterwards planted in suitable soil, &c. *Offsets* are small bulbs which are produced round the base of larger ones, and, being taken off and planted, become plants. *Tubers* are underground stems, containing leaf-buds; and these may be separated and planted entire, or cut into as many pieces as there are buds, in either of which cases new plants will be formed. *Layers* are branches or shoots of either woody or herbaceous plants, which are bent down, and a portion of their length buried a few inches in the soil; that portion having been previously wounded by cutting, bruising, or twisting, which, by checking the descent of the sap, gives rise, after a certain period, to the production of roots. After these roots are formed, the portion of the layer which has produced them is separated from the main stock or parent plant, and planted by itself. *Cuttings* are portions of shoots, either of ligneous or herbaceous plants, entirely separated from the parent and planted under suitable conditions, which vary with different species. They are made of the young shoots with the leaves on, or of the ripened wood either with or without its leaves; and after they have, either in a herbaceous state with the leaves on, or with the wood mature and with or without the leaves, been properly prepared and planted, they form roots at their lower extremity, each cutting becoming a perfect plant. In general, cuttings should be taken from those shoots of a plant which are nearest the soil; because, from the moisture and shade there, such shoots are more predisposed to emit roots than those on the upper part of the plant; neither excessively vigorous nor very weakly shoots should be chosen, and the young or last-formed shoots are in most cases to be taken in preference to older shoots, though in some instances it is necessary that they should be nearly matured before being removed. The cutting is to be prepared by paring away with a very sharp knife its lower extremity just below a joint, the lenticels or root-buds being there most abundant. When the cutting is planted, the principal part of the art consists in making it quite firm at the lower extremity, so as completely to exclude the air from the wounded section. Cuttings emit roots at this section, either in consequence of the action of the accumulated sap in the cutting, as in the case of the ripened wood in deciduous trees and shrubs; or in consequence of the joint action of the accumulated sap and of the leaves, as in the case of cuttings of soft wood with the leaves on, and in a living state. A few plants are propagated by cuttings of the leaves, the petiole of the leaf being slipped off from the parent plant, and probably containing the latent embryos of buds; and some plants are increased by fragments of the fleshy leaves themselves, as in *Begonia* and *Gloxinia*.

Grafting and budding are processes which have been already explained. [BUDDING; GRAFTING.] Inarching may be described as a species of grafting, in which the scion is not separated from the parent plant till it has become united with the stock.

Propeds. The name given by Kirby to the soft, fleshy, inarticulate, pediform appendages of certain larvæ, placed behind the true feet, and disappearing in the mature insects.

Propeller. [STEAM NAVIGATION.]

Propempticon (Gr. from προπέμπτω, *I send forth*). In Literature, a poetical address to one about to depart on a journey. Perhaps the finest in existence is that of Schiller to the duke of Weimar when about to visit France.

Proper. In Heraldry, any object represented of its natural colour is so termed.

Proper Motion. In Astronomy, the real motion of the sun and stars through space, as opposed to apparent motion, produced by the actual movement of the earth. It was first suspected by Halley in 1718. (*Phil. Trans.* vol. xxx. pp. 736–8.)

Property. In Logic, a predicable which denotes something essentially conjoined to the essence of the species. There are enumerated in books on logic four kinds of property, which are termed *universal, but not peculiar; peculiar, but not universal; universal and pecu-*

liar; universal and peculiar, but not at every time. The last kind is more properly designated as *accident*. [LOGIC; PREDICABLE.]

Prophet. The Greek word προφήτης denoted strictly one who speaks for another, and especially one who speaks for a god and interprets his will to men. Thus Teiresias is called by Pindar the prophet or interpreter of Zeus, and the Pythian priestess is called the prophetess of Apollo, and poets the prophets or interpreters of the Muses. In the New Testament the word is used commonly by St. Paul and in the Acts of the Apostles to signify an interpreter of Scripture, a preacher. (Liddell and Scott, *Greek and English Lexicon*, s.v. προφήτης). In the Hebrew Scriptures, persons who declared the will of God are called at first *seers*, and afterwards *nabi*, or *prophets*, who spoke as moved by the Spirit of God; but prophecy 'in its more extensive meaning comprehended the whole course of religious education,' this instruction being given in schools called the schools of the prophets. The outward gestures of the prophets indicated sometimes an excitement not unlike that of the Pythian priestess, as in the instances recorded of King Saul. (1 Sam. x. 11; xix. 24.) The word *prophecy* was also used to express the occurrence of marvellous events. Thus the body of Elisha is said to have prophesied, in reference to the revivification of the dead Moabite on coming into contact with his bones. A further meaning of the word was that of prediction or the foretelling of future events; and the Book of Jonah, which relates the disappointment and indignation of the prophet at the non-fulfilment of his prophecy in its literal meaning, seems pointed at an exaggerated theory then prevalent respecting this characteristic. The great Hebrew prophets were, pre-eminently, fearless spiritual teachers, who appeared among their countrymen to declare the Divine Will at all costs and at every sacrifice, and to assert the existence of a moral law which godless rulers and a superstitious people were tempted to ignore or to defy. 'But, setting aside their Divine commission, the prophets were the great constitutional patriots of the Jewish state; the champions of virtue, liberty, justice, and the strict observance of the civil and religious law, against the iniquities of the kings and of the people.' (Milman, *History of the Jews*, book viii.) The Old Testament contains sixteen prophetical books, viz. those of the four termed the great prophets, Isaiah, Jeremiah, Ezekiel, Daniel, and the twelve lesser prophets, Hosea, Joel, Amos, Obadiah, Jonah, Micah, Nahum, Habakkuk, Zephaniah, Haggai, Zechariah, Malachi.

Prophylactic (Gr. προφυλακτικός, from προφυλάσσω, *I defend*). In Medicine, this term is used to denote the means employed to prevent disease.

Propionic Acid. *Metacetic acid. Metacetonic acid.* A crystalline acid closely related to acetic acid and formed by oxidising oleic acid. It is also produced by the reaction of cyanide of ethyl and alcoholic solution of potash, and by the action of sodium ethyl upon carbonic acid.

Propolis (Gr.). A name applied to the substance employed by bees in closing up crevices in their hives, and in strengthening the margins of the cells of the comb. It is a glutinous resin, of a reddish-brown colour and an aromatic odour, and in time acquires a firm consistence. It is collected from the wild poplar and other trees. [HIVES.]

Proportion (Lat. proportio). In Arithmetic and Geometry, the equality or similitude of ratios; four numbers or magnitudes being said to be proportional, or in proportion, when the ratio of the first to the second is the same as the ratio of the third to the fourth, or when the first divided by the second gives the same quotient as the third divided by the fourth.

The definition of proportion has given rise to much controversy among writers on the elements of Geometry. Euclid's celebrated definition in the fifth book, whatever may be said in favour of its ingenuity and exactness, is found by experience to be much too complicated and refined to be understood by beginners; and accordingly many attempts have been made to substitute for it one more intelligible; but, on account of the difficulty of defining the term *ratio* in such a manner as to include incommensurable quantities, none of these attempts can be said to have been perfectly successful. This imperfection, however, must be understood as belonging merely to the metaphysical accuracy of the definition, for many of the treatises which have been composed with the view of superseding Euclid's have all the simplicity and elegance which can be desired. On this subject the reader may consult Barrow's *Mathematical Lectures*, the notes to Playfair's *Euclid*, Camerer's *Euclid*, Berlin 1825; De Morgan *On the Connexion of Number and Magnitude*, 1836; and the article 'Proportion' in the *Penny Cyclopædia*.

Proportion consists of, at least, four terms; of these the two which constitute the antecedents, as well as the two which form the consequents of the equal ratios, are said to be *homologous terms*. When, in a proportion, the antecedent of one ratio is equal to the consequent of the other, the three unequal magnitudes are said to be *continual* proportionals; in other cases the proportion is said to be *discrete*. Two quantities of the same kind are said to be *directly* proportional to two other quantities like each other and respectively related to the first, when in equal ratios the two related quantities are either both antecedents or both consequents. When the quantity related to the antecedent of one ratio, however, is the consequent of the other, the proportion is said to be *inverse*, and two of the magnitudes are said to be *inversely* or *reciprocally* proportional to their, respectively, related magnitudes.

It is a property of proportional numbers, derived immediately from the definition, that the product of the first and fourth terms is equal to the product of the second and third.

Hence, when three terms of a proportion are given, the fourth can be found. This is the object of all questions in the Rule of Three.

The preceding remarks apply exclusively to *geometrical* proportion; i.e. when the proportion consists in the equality of ratios. Writers on arithmetic also mention *arithmetical* proportion, and *harmonical* proportion, for which see the respective terms. [ARITHMETICAL PROGRESSION; HARMONIC PROGRESSION.]

PROPORTION. In the Fine Arts, the most proper relation of the measure of parts to each other and to the whole. The Greeks used the word συμμετρία (*symmetry*), to express this idea. In many instances *proportion* may be considered almost synonymous with *fitness*, though there is a distinction between them; since every form susceptible of proportion may be considered either with respect to its whole as connected with the end designed, or with respect to the relation of the several parts to the end. In the first case, fitness is the thing considered; in the second, proportion. Fitness, therefore, expresses the general relation of means to an end, and proportion the proper relation of parts to an end. It is hence needless to dwell on the intimate connection that exists between beauty and proportion, in all complex forms.

Proportions, Definite. In Chemistry. [AFFINITY.]

Proportional Compasses. Compasses with two pairs of opposite legs, by which distances are enlarged or diminished in any proportion.

Proportional Logarithms or **Logistic Logarithms.** This name was given to tables (intended to be used with the old *Nautical Almanac*) by which the fourth proportional to three given numbers, of which the first never varied, could be conveniently found. They are now rarely used.

Proportional Parts. A name given in logarithmic and other tables, to other small tables introduced for the purpose of facilitating interpolation. In each set of tables, the use of the table of proportional parts is usually fully explained.

Proportional Scales. [SCALES.]

Proportionals. The terms of a proportion; of these the first and last are the *extremes*, and the intermediate the *means*, or the *mean* when the proportion consists of only three terms. [PROPORTION.]

Proposition. In the scholastic system of Logic, a proposition is defined *a sentence indicative*; i.e. a sentence which affirms or denies. Thus, sentences in the form of command or question are excluded from the character of propositions. Logical propositions are said to be divided, first, according to substance, into *categorical* and *hypothetical*; secondly, according to quality, into *affirmative* and *negative*; thirdly, according to quantity, into *universal* and *particular*. 1. A categorical proposition affirms or denies absolutely, as 'Man is mortal.' A hypothetical proposition is defined to be two or more categoricals united by a conjunction, as 'If Caius is man, he is mortal.' There are several sorts of hypothetical propositions: *conditional*, *disjunctive*, *causal*, &c. But all disjunctive hypotheticals may be resolved into two or more conditional propositions, 'Either A is B or C is D,' being equivalent to 'If A is not B, C is D,' and 'If C is not D, A is B.' Hence their disjunctive character arises only from their form, their meaning being in all cases conditional. In such propositions no assertion is made of the truth of either proposition, all that is maintained being the inferribility of the one from the other. Thus in the proposition, 'If the Koran comes from God, Mahomet is the prophet of God,' the real subject of predication is the whole proposition, 'Mahomet is the prophet of God,' the affirmation being that this is a legitimate inference from the proposition, 'The Koran comes from God.' Hence the subject and predicate of hypothetical propositions are names of propositions. (Mill, *System of Logic.*) 2. An affirmative proposition is one whose copula (or conjunction) is affirmative, as 'Man is mortal;' a negative proposition has a negative copula, as 'Tyrants are not happy.' 3. A universal proposition is when the predicate is said of the whole of the subject, as 'All men are mortal,' 'Caius is mortal;' a particular, when it is said of part of the subject only, as 'Some men are rich.' To these two species may be added the indefinite proposition, when the subject has no sign of universality or particularity, or is a singular noun, which is either universal or particular according to the matter. The matter of a proposition is said to be either *necessary*, *impossible*, or *contingent*; and if the matter of an indefinite proposition be either of the two former, it is equivalent to a universal; if the last, to a particular: e.g. 'birds fly,' i.e. all birds —universal. 'No birds are quadrupeds;' here the matter is impossible, and the proposition universal. 'Birds sing,' i.e. some birds—particular. The fourfold division of propositions according to quality and quantity is denoted by arbitrary signs; e.g. A stands for a universal affirmative, in the logic used at Oxford; E for a universal negative; I for a particular affirmative; O for a particular negative. A categorical proposition is composed of two terms united by a copula. [TERM; COPULA.] The first term, i.e. that of which the other is affirmed or denied, is the *subject*; the other (that which is affirmed or denied respecting the first) the *predicate*. In the collocation of our language, the subject usually, but not invariably, precedes the predicate. Thus, 'Diana of the Ephesians (subject) is great' (predicate), is transposed into 'Great is Diana of the Ephesians.' In some languages, as Greek and Latin, the latter form of collocation is not less natural or usual than the former. When the subject of a proposition is a common term [TERM], it is said to be *distributed*, when the universal sign (*all*, *no*, *every*, &c.) is prefixed and the proposition is consequently universal. The predicate is said to be *distributed* in all ne-

gative but not in affirmative propositions, inasmuch as a negative proposition denies that any part of the predicate agrees with the subject, whereas an affirmative can *never* assert that every part of the predicate agrees with the subject; i.e. can never do so necessarily, by the logical force of the proposition, although it may undoubtedly happen that the predicate agrees with the subject and with nothing else: e.g. 'Cæsar was the first Roman emperor.' Two propositions are said to be opposed, when, having the same subject or predicate, they differ in quantity, in quality, or in both. The two universals (A and E) are termed *contraries* to each other; the two particulars (I and O) *subcontraries*; the universals and particulars (A and E, I and O) *subalterns*; A and O, or E and I (those which differ both in quantity and quality), *contradictories*. A proposition is said to be converted when its terms are transposed; i.e. when the subject is made the predicate, and the predicate the subject. [CONVERSION.]

It must be carefully remembered that propositions relate not to words or to our ideas of things, but to things or facts, in other words to phenomena; all propositions, affirmative or negative, being assertions that of two phenomena one agrees with, or includes, or is connected with the other, or that it does not so agree with it. The proposition 'Fire burns' cannot be resolved into the assertion that our idea of fire causes our idea of heat: it can mean only that the natural phenomenon fire causes or is followed by the natural phenomenon heat. If we wish to assert anything respecting ideas, we speak of those ideas by name, as when we say, 'The ideas entertained of the Deity have a great effect on the characters of mankind.' 'The notion,' says Mr. Mill, 'that what is of primary importance to the logician in a proposition is the relation between the two ideas corresponding to the subject and predicate (instead of the relation between the two phenomena which they respectively express) seems one of the most fatal errors ever introduced into the philosophy of logic.'

PROPOSITION. In Mathematics, a theorem proposed to be demonstrated, or a problem in which something is proposed to be done.

Proprætor. A Roman magistrate, bearing to the prætor the relation which the proconsul bore to the consul. [PROCONSUL.] Under the emperors, proprætors, as distinguished from proconsuls, were appointed as governors to the imperial provinces, the latter being the servants of the senate.

Propylæa (Gr. προπύλαια). Strictly, the entrance to a temple or sacred enclosure. But when the term is not specially used of Egyptian temples, it denotes generally the entrance to the Acropolis of Athens. These propylæa were completed in the time of Pericles, B.C. 432, the cost being upwards of 2,000 talents. The building was in the Doric style, and the architect was Mnesicles. (Leake, *Topography*, c. viii.; Beulé, *L'Acropole d'Athènes*; *Edinburgh Review*; July 1859.)

Prorogation (Lat. prorogatio). The continuance of the parliament from one sitting to another by command of the crown, whereby all business is suspended, and proceedings, with one or two exceptions, quashed. [PARLIAMENT.]

Proscenium (Gr. προσκήνιον, from πρό, and σκηνή, *a tent*). In Architecture, the frontispiece, or part in a theatre where the drop scene separates the stage from the audience; it is situated beyond the orchestra. In ancient theatres it comprised the whole of the stage.

Proscription (Lat. proscriptio, *an outlawry*). The most vindictive species of proscription was that introduced by Sylla when he wrested Rome from the hands of the Marian faction. It consisted in making out a list of persons supposed to be obnoxious to the state, and getting a sentence of condemnation passed, which made it unlawful to harbour them. By these measures thousands of citizens perished in the civil wars of Rome. The most celebrated proscription was that of the triumvirs, Octavius, Antony, and Lepidus, in which Cicero was slain.

Prose (Lat. prorsa oratio; from prorsus, adv., *direct* or *straightforward*). In Literature, all language not in verse. Prose diction, to be good, or even admissible, in ordinary criticism, must be conformable to the rules of composition as to style, cadence, &c.

Prosecution (Lat. prosecutio, *a pursuing*). In Law, the popular rather than legal name for the collective steps taken in order to bring an alleged offender to trial and conviction. The law of England differs from that of other countries in having no office analogous to what is termed in France *ministère public* for the prosecution of offences. At common law, therefore, and in the great majority of cases, the so-called *prosecutor* is merely the person injured by an offence, who in the first instance obtains a summons or warrant against the accused. In case of injury to the public, however, the Attorney-General is the recognised public prosecutor; and sometimes government originates proceedings in private cases of great importance or scandal: while informations for misdemeanours, in many statutable cases, are *prosecuted* by the informer.

Proselyte (Gr. προσήλυτος, *one who arrives as a stranger*). A term in use among the Jews after their connection with the Greeks, and applied to such foreigners as embraced their religion. These they divided, according to the common opinion, into two classes, distinguished by the terms *proselytes of the gate* and *proselytes of righteousness*. Of these the former were such as merely renounced idolatry, and believed in and worshipped the true God, receiving their name from being admitted within the first gate of the temple. The latter class were those who submitted to circumcision, and in every other respect conformed entirely to the customs of the Jewish people. Dr. Burton, however, thinks this distinction unfounded (*Lectures on the Eccl. History of the First Three Centuries*, i. iii.), and it probably is so as regards the Jewish national history,

having been introduced by the Rabbinical body from two to five centuries after the Christian era. (Smith, *Dictionary of the Bible*, s.v.)

Prosenchyma (Gr. προσεγχέω, *I pour still more upon*). In Botany, that form of cellular tissue the cellules of which taper to each end, and consequently overlap each other at their extremities. It is the first approach on the part of cellular tissue to the condition of woody tissue.

Proserpine. In Mythology. [PERSEPHONÊ.]

Prosody (Gr. προσῳδία). The science which treats of quantity, accent, and the laws of harmony, both in metrical and prose composition. In the Greek and Latin languages every syllable had its determinate value or quantity, and verses were constructed by systems of recurring feet, each foot containing a definite number of syllables possessing a certain quantity and arrangement. [FOOT.] The versification of modern European languages, in general, is constructed simply by accent and number of syllables. They have, therefore, no prosody strictly so called. The Germans, however, have laboured to subject their language to the ancient metrical system, but with indifferent success. (Hallam, *Lit. Hist.* pt. i. ch. i. p. 29.)

Prosopis (Gr. πρόσωπον, *a visage*). A genus of Leguminous plants of the sub-order *Mimosæ*, consisting of trees found in various tropical countries, and remarkable for having their pods filled in between the seeds with a pulpy or mealy substance. Thus *P. dulcis*, which, with several varieties often described as distinct species, is widely spread over Central and Southern America, is sometimes planted for its sweetish succulent pods, used for cattle-feeding, called Algarobo, after the Spanish Algarobo or *Ceratonia*, which it resembles in flavour. *P. spicigera*, in the East Indies, has also a sweet pod, there compared to the Algarobo. The pods of several species supply a large quantity of tannin. *P. glandulosa*, the Mezquit of Texas and the regions to the West, yields excessively hard and durable timber, and likewise affords a large quantity of gum resembling gum-arabic.

Prosopite (Gr. προσωπεῖον, *a mask*, from its deceptive or masked condition). A rhombic variety of Fluor Spar found at Altenberg in Saxony in brilliant dark blue crystals or in every state of alteration into Kaolin. It may be either a new dimorphous variety of Fluor, or pseudomorphous after Heavy-spar or Datholite.

Prosopography (Gr. πρόσωπον, *figure* or *person*, and γράφω, *I describe*). In Rhetoric, a word used by some critical writers to signify the description of animated objects.

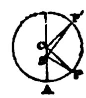
Prosopopœia (Gr. πρόσωπον, and ποιέω, *I make*). A figure by which inanimate objects or abstract ideas are personified, and addressed or represented by the poet or orator as if endowed with human shape or sentiments. Milton's famous digression of Sin and Death, in the *Paradise Lost*, is at once a prosopopœia and an allegory. [PERSONIFICATION.]

Prospectus (Lat.). In its most extended sense, this word is applied to the outline of any plan or proposal submitted for public approbation; but it is most usually confined to literary undertakings, in which it signifies an outline or sketch of the plan or design of a work, together with such other circumstances connected with the publication, &c., as it may be thought desirable to enlarge upon or make known.

Prostate Gland. In Comparative Anatomy, the prostate gland retains its single compact form in most of the Quadrumana, but is bifid in the Ruminantia. In the Rodentia and Insectivora it is resolved into numerous slender elongated cæcal tubes; in the mole it is remarkable for its periodical increase of size.

Prostates (Gr. προστάτης). The name given to the guardians of the foreign settlers at Athens, whose business it was to represent them in courts of law, and protect them from injury. [METŒCI.]

Prosthapheresis (a word made up from Gr. πρόσθεν, *in front of*, and ἀφαίρεσις, *subtraction*). A term used by the older writers on Astronomy to signify the difference between the true and mean motion, or the true and mean place of a planet, or the quantity which must be taken from or added to the mean anomaly, in order to get the true anomaly. Let P (or P′) be the place of a planet in its orbit, S the sun, C the centre, and A the perihelion of the orbit; the angle A S P is the true anomaly; A C P is the mean anomaly; and the difference between ASP and ACP is SPC, which is the prosthapheresis. If ACP be less than a right angle, SPC must be added to ACP in order to get the true anomaly; but if it be greater than a right angle the angle SPC must be deducted. The angle SPC is called by modern writers the equation of the *centre* or equation of the orbit.



Prosthesis (Gr. *an addition*). A figure of Grammar by which one or more letters are prefixed to a word; as in the common English participles, *be*loved, *be*reft, &c. [METAPLASM.]

Prostyle (Gr. πρόστυλος). In Architecture, a temple with a row of detached columns on its front elevation.

Prosyllogism. In Logic, a word sometimes used to signify a second syllogism, proving a former one; at other times in the same sense as enthymeme, viz. a syllogism of which one premiss is suppressed.

Protasis (Gr. literally *a stretching forth*). In Grammar and Rhetoric, every properly constructed PERIOD is said to be naturally divisible into two parts; of which the first is termed *protasis*, the second *apodosis*. In the ancient drama, the protasis was the exposition, usually contained in the first part of the piece, either by way of soliloquy or dialogue, serving to make known the characters and the plot to the audience.

Proteaceæ (Protea, one of the genera). A large natural order of arborescent, rigid Exo-

gens, of perigynous structure, belonging to the Daphnal alliance. They inhabit the hotter parts of the world, and are found growing in dry, sterile, stony, exposed places, especially near the sea-coast. They are distinguished by their irregular calyces having a valvate æstivation, by their apetalous flowers, by their anthers bursting lengthwise, and by their erect ovules. The genera *Banksia*, *Dryandra*, *Protea*, and *Grevillea* are cultivated for the sake of their beautiful foliage and flowers. The seeds of *Guevinia* are sold in Chili for the same use as hazel nuts with us. One of the larger timber-trees of New Zealand is the *Knightia excelsa*, a plant of this order.

Protection (Lat. protectio, *a covering*). In Political Economy, the indirect advantage which the legislature of any country gives to the sale of one or some among the productions of that country, with a view either to compensate the producer for some real or supposed disadvantages of a permanent kind under which he labours in competition with a foreign producer, or to aid in the developement of some nascent and imperfect manufacture. The means by which this advantage is accorded, is either by a duty levied on a foreign commodity, the home produce remaining duty free, or by a higher duty levied on the foreign than on the home produce, or by differential duties levied on the produce of foreign countries and colonial dependencies, or by the absolute prohibition of import. All these methods of protection have been adopted in this country at different periods of its economical history. An example of the first kind is to be found in the sliding scale of the old corn laws, and the shilling duty of the new; of the second, in the duties levied on foreign spirits as compared with the excise on home produce; of the third, in the colonial sugar and timber duties; of the fourth, in the bygone prohibition of the importation of Irish cattle. Most protective regulations have been eliminated from the English tariff; but all nations have conceived, and by far the largest number still conceive, that there is great wisdom, patriotism, and security in maintaining a protective system, despite the almost unanimous reasonings of economists, and the convincing experience of the benefits which result from an opposite policy. In the interval between ignorance and enlightenment as to the folly of protection, the practical refutation of the system is found in the encouragement and the sympathy given to the trade of the smuggler, a fraud on the revenue which administrations punish severely in their own case, and encourage studiously in dealing with foreign states. Thus, to encourage smuggling formed a necessary part of the English policy in retaliation for the Berlin edict; and so successful was this policy, that, notwithstanding Napoleon's influence over Europe in the first ten years of the present century, and the measures taken to enforce the decree, his own soldiers were clothed in English produce; and similarly the chief value of Gibraltar for many years was its convenience as a dépôt for smuggling goods into Spain. It is obvious that when the interest of a community is understood to consist in freedom of trade (and of this there can be no doubt as regards the export of its own products, whatever view may be entertained or enforced about imports), offences against the revenue, which are really wrongs inflicted on the tax-paying portion of the community, will be looked on with great leniency; a serious collision must needs arise between the public conscience and private interest, and a low tone of public morality will ensue. [SMUGGLING.]

It is observed that protection is accorded either by way of compensation or encouragement, and these are the two purely economical aspects of this kind of legislative action. But there are others which are social or political, and demand attention. It is sometimes alleged in defence of protection, that it enables a country to be more or less independent of foreign produce and foreign policy, and again that it tends to create a large social variety in the community. For instance, it is asserted that, if any country depends largely for any kind of produce upon supplies from foreign countries, it is in the power of such countries to starve or cripple the importing country by withholding the exportation, and (if needful) by compensating such members of the community as have produced in the hope of a foreign market. In the next place, it has been urged, that by encouraging, at least temporarily, the growth of some manufacture, the real advantage of variety of occupation will be secured to the community, and with it the benefits actual, or imaginary, of such a social reciprocity of feeling, education, and habit, as are supposed to arise from the due admixture of agricultural and commercial interests, and from the convenience of being provided, in case the cessation of any foreign supply takes place, with the home growth of the articles or utilities which might otherwise have been derived exclusively from external sources. Both these objections apply to imports. All civilised nations without exception desire to secure themselves a foreign trade, because unless they export commodities the accumulation of wealth is rapidly and permanently checked. Some of these arguments have been admitted and endorsed by eminent economists. A little attention, however, it is to be hoped, will be sufficient to show that both fears and benefits are equally imaginary.

In the first place, it may be observed, that the only commodities the prohibition of exporting which might affect an importing community, are grain and the raw material of clothing. Everything else could be dispensed with, and the prohibition, by destroying the trade of the producing country, would simply inflict an injury on the prohibiting community instead of a loss on the importing one in case the demand ceased. For instance, if the French or Spanish government were to prohibit the export of wine from their countries to England, the nation would either do without wine, or

draw its supplies from other sources, or, what is more likely, the wines of Spain and France would be sent to some port in some other country, and thence imported into England; and the result would be, that, first, the wine would be burdened with the cost of a circuitous carriage, and, next, the country which acted as a go-between would derive the advantage of lower prices from the producer, in consequence of the necessity which existed of exporting the produce, and the adoption of the only possible means of export. As regards the first necessaries of life, i.e. grain and the raw material of clothing, it is almost superfluous to say that they are very widely dispersed; that no country has a monopoly or sole production of them, except under very rare circumstances, and then only in one kind; and that therefore the inconvenience inflicted on the foreign market would be temporary, while the loss on the home producer would be lasting, because his market would be rendered uncertain. But, in effect, the practical refutation of this theory of dependence on foreign markets, and the risk of a prohibitory duty being laid on exports, lies in the fact that it has rarely been attempted, and has never been attended with the effect anticipated. As we have said before, it is in the first place contrary to the manifest interests of the producer, and is therefore unpopular and nearly certain to be evaded, either by smuggling or by transshipment, and in the next, other means and other sources are found to compensate the loss. Thus, during the French war, the English government prohibited the importation of saltpetre, and prevented that of sugar into France. The consequence was that nitre was procured from home sources, and the cultivation of beet received so powerful a stimulus in France as to make it a permanent object of industry. Similarly the cessation of the cotton supplies seemed to the leaders of the Confederate party in the Southern States of America so vital a question to English industry, that this country would be forced into a recognition of the Confederacy, if not into active aid. But though the local distress was great, the compensation supplied by other and analogous branches of manufacturing industry more than counterbalanced the loss of the cotton manufacture, and none of the political consequences which were anticipated ensued. But if so little resulted from the arrest of the cotton supply, the greater part of which was supplied from one region, how much less likely is it that any local prohibition of the export of grain should affect to any considerable extent the supplies derived from external sources. It is impossible to conceive such a state of things, unless every particular country which needed more grain than it could produce were at war with all mankind at once, and, to use an analogy which precisely represents such a status, were put into a state of siege by the whole world. So idle was the alarm which was frequently expressed during the time when the great economical struggle of twenty years ago was going on, as to the consequence of dependence on the foreigner. To depend on the foreigner as much as possible is to make the foreigner depend on oneself, for all nations are equally desirous to export their goods. Everybody who produces desires to sell, and the wider the market, the more certain is the purchase, the larger the aggregate profit of the transaction.

The argument that there is a social benefit in such a protective system as insures a diversity of occupations is a favourite mode of reasoning with the American protectionists, and is insisted on with great vehemence by Mr. Carey, almost the only economist of any reputation who has maintained every fallacy in favour of protection. But, in the first place, the argument starts with an unwarranted and unproved hypothesis, that benefit arises on purely social grounds from a diversity of occupations. Every nation must possess some manufactures, and it is certain that the manufactures of other countries must compete unequally (by reason of the charges of transport and the risks of a market—no trifling deductions) with those of home growth. A manufacturing class must therefore exist, and be the object of a *natural* protection. Besides, if one occupation is to be fostered on social grounds, why not all? If the ironmaster of Pennsylvania, and the cotton-spinner of New England, is to be protected, why not the author of Boston or elsewhere? If an American's body should be clothed only in fabrics of native work, why should an American's mind be enlightened by the labour of any other than an American's thoughts? To say that protection is to be afforded to certain branches of industry *only*, in order that the social benefits of every diversity of occupation should be secured, is an absurdity transparent to all except to the selfish instincts of particular producers. Protection on these grounds, to be just and consistent, should be accorded to all alike; and if everyone were thus protected, everybody would pay more for everything he needed, in other words he would get less for more labour; and even if some social advantage ensued from the stimulus given to plurality of occupations, still, as the protection must needs be accorded to the producers of the chief necessaries and conveniences of life (else the articles could be dispensed with, and the protection rendered nugatory), it may be doubted whether this is not more than compensated by the general loss inflicted on the community in the enhanced cost of such commodities. That the energy of American invention and industry stands in no need of any protective aid, and that therefore attempts to introduce prematurely any kind of occupation by legislative enactment are unnecessary, is proved incontestably by the extraordinary aptitude which the nation possesses of applying mechanical forces in aid or substitution of manual labour.

It remains to advert to the arguments by which protection has been defended in this

country, arguments which have been quoted summarily in the definition prefixed to this article. It is said, for instance, that the existence of a duty in foreign countries levied on articles produced in this, should be met by similar duties on imports. But the practical refutation of such a reciprocal loss has been supplied by manufacturers themselves, who have never during the last forty years ceased to importune the legislature to leave them free from such questionable aids. The most persistent claim, however, to protection was made by the landed interests, and the plea invariably alleged was the peculiar burdens laid on land, burdens which made it impossible for the farmer to compete profitably with the low prices of foreign produce. The result of this plea was the imposition of the CORN LAWS and the machinery of the sliding scale. The assertion that peculiar burdens are laid upon land, is a singular example of the facility with which a wholly baseless statement may gain credence when it is boldly and dogmatically repeated. Not only is it the case that there are no peculiar burdens upon land, but in fact the landowner has several distinct benefits accorded to him by the legislature. He did not till lately pay any succession duty, and even now real property pays at a far less rate than personal. He takes precedence of other creditors in the full payment of all debts due to him. His tenant's stock pays no insurance duty; and as insurance is part of the cost of production, and rent is all that remains after the cost of production is satisfied, he naturally gets added to his rent the tax which others pay for insurance. The duty on corn, although small, nevertheless affects all corn sold, as long as any is imported, and cannot raise on an average of years the price of all sold by less than a million and a half. He is able to borrow government money at lower than the market rate of interest. Poor rates, which have been shown to be really an insurance on labour, and therefore a deduction from wages, are paid by occupiers, i.e. by all alike instead of falling on employers of labour only. Highway rates, i.e. payments for the repair of roads, are, economically speaking, the machinery for supplying a necessary instrument to the agriculturist, i.e. the means of transit. These are also supported by all occupiers alike, and the last are maintained by tolls levied on the general public, the true wear of the road being the work of the farmer, who generally escapes the impost. It is not possible to advert to any tax which should be paid from land which is not, either wholly or in part, diverted upon some other kind of property or income. There is not the smallest warranty for asserting that land is affected by any peculiar burdens; while it is perfectly certain that, without any labour being expended upon it, land rises in value with the increase of population, and with the wealth and demands of the nation. But even if it had been the case that land had been exceptionally burdened, a protective system was the worst possible remedy for the inconvenience. It raised the price of one commodity, wheat, and dwarfed the price of all other agricultural produce. It insured a varying market for that which it professed to sustain, and thus inflicted the extremes of profit and loss on the producer, and it stereotyped a low market for every other thing which the farmer had to sell; for the greater part of the income of the greater part of the population being absorbed in the purchase of bread, a scantier margin was left for the purchase of meat, dairy produce, wool, and the other commodities which the farmer supplies. Thus we may confidently predict, that if at any time a great rise should take place in the price of bread, a great fall will take place in the price of all other farm produce, and the fancied gain on one side will be inconveniently balanced by a real loss on the other. No one is more interested in cheap bread than the landowner.

The remaining argument upon which protection is recommended, that it may support during its infancy some manufacture or branch of industry, not, as some American economists assert, for the benefit of society by encouraging all kinds of occupation, but as a means for developing in a new country a produce for which it is peculiarly fitted, and which it could not otherwise, as is presumed, have entered upon, has even been approved by Mr. Mill, *Principles of Political Economy*, book v. c. x. s. 1. The passage has often been quoted by protectionists in America and the colonies, as a complete apology for all such theories as have been put forward in those countries; and though it is not just to Mr. Mill, that, in spite of his strong protest against protection in the remainder of the chapter, his view should be cited as a vindication of protective extravagances, yet there is a dangerous latitude in his words, and an apparent authority is given to these delusive schemes.

Mr. Mill surrounds his case with cautions. The protection should be temporary, the industry should be suitable, and the aid should be granted only for such time as shall secure a fair trial. Mr. Mill does not say that the country must needs be young and rising, but considers this to be the most natural field for the experiment. He implies apparently that the community adopting protection for this limited period, should be equally able or perhaps better able to compete with another country in which the manufacture is already settled, provided this fair trial be accorded. It is plain indeed that, economically speaking, there is no difference between the case of a young country which begins an industry familiar to old countries, and that of an old which discovers the material for another industry not at present practised by itself, but occupied by one or two other communities. Newness does not lie in the country, but in the occupation followed in it. But, it may be asked, who is to judge of the time necessary for a fair trial of the

legitimate significance of a new set of conditions and of the suitableness of the industry? Every country, as has been said above, manufactures something. Every country has a natural protection for its own produce in the charge of carriage and the risk of the market contemplated by the importer. These appear to be the fairest set of conditions which can be supplied to any country for the adoption of a manufacture hitherto unknown, and to have been, historically speaking, completely sufficient for the growth of new industrial occupations in any community. Nor must we forget, that if protection be effectual, it not only taxes the purchaser of the protected commodity, but diverts the capital which could be employed for other products which need no protection. It not only inflicts a loss on consumers, but one on producers. And in young and rising countries, where the rate of interest is inevitably high, any diversion of capital from its natural channels, i.e. those in which it is, under existing circumstances, most productive, is a tax of the heaviest and most wasteful kind, and one which needs the most cogent reasons for its imposition—reasons little, if indeed at all, short of the urgent necessities of public safety.

There will probably never be wanting, in pursuance of Mr. Mill's hypothesis, plausible reasons for concluding that the conditions which he has alleged as justifying a temporary protection apply to many forms of industry, and for urging that public interests and even public safety are concerned in the aid to be given to special kinds of manufacture. But all these reasons, it may be submitted, are founded on particular instead of general interests. The developement of any branch of industry in countries or rather in localities for which it is most fitted, is a matter not only of national, but of what is far more important, human interests; and the general acknowledgement that a fair trial is to be sought only in letting things take their due course would do more towards breaking down the artificial barriers which separate the great families of the human race than any other conceivable means. It may unhappily be the case hereafter, as it has too frequently been the case hitherto, that motives of policy may be urged and may be employed in order to control and coerce industrial action, as well as to sow international jealousies. But the more thoroughly nations are taught to understand that their best interests are consulted when they depend on each other, and that for all economical purposes the civilised world is or should be but one community, the more certain is it that the harmony of purposes which would be fully effected were such a sentiment general, is being made complete. Political economy is not the wealth of a nation, but the wealth of all nations.

Some of the most ingenious illustrations of the fallacies of protection are to be found in the works of Bastiat, and perhaps among these none is more striking than that contained in a whimsical petition purporting to come from the various traders and manufacturers of artificial light, who are supposed to pray the Chamber of Deputies to grant them protection against the importation of that foreign produce, the light of the sun.

In this country, indeed, protection has not been abandoned, nor can it be said to have been abandoned so long as any privilege is given to any class of persons. That such privileges should be accorded is, of course, a question of public policy into which it is not possible to enter here. But the question is virtually decided as far as it relates to trade, agriculture, and manufacture, by the principle, now fully admitted, that any exceptional right, though not necessarily impolitic, though very possibly advantageous to the public interests, is nevertheless continually on its trial, and must needs vindicate its public utility before it can command present respect or secure itself ultimately from extinction. To have gained the acknowledgement of such a principle, is more important than the application of free trade to a few insulated cases.

Protectionist. In Politics, a name popularly given to those who maintain the principle of protection to native industry against that of free trade: in particular, to the party which opposed the repeal of the corn laws. The 'Society for the Protection of Agriculture' was dissolved in 1853 on Lord Derby's refusal to propose the restoration of those laws.

Protector (Lat. *a defender*). In English History, a title which has been three times borne by daring statesmen: 1. Richard, duke of York, in 1453, was appointed by parliament protector during pleasure. 2. The duke of Somerset, being constituted one of the sixteen executors of Henry VIII., obtained a patent from the young king, Edward VI., in 1548, constituting him protector, with the assistance of the other fifteen as councillors; but he enjoyed this dignity only a few months, and his loss of it was soon followed by his death. 3. Cromwell took the title of lord protector of the commonwealth of England, Scotland, and Ireland, on December 12, 1653, when the *Barebones Parliament* resigned its authority into his hand. His son Richard succeeded him in his title and authority, but was never formally installed protector.

Protein (Gr. *πρῶτος, first*). The azotised substance which forms the basis of albumen, fibrin, and casein, in which proximate principles it is combined with small proportions of sulphur and phosphorus. Different formulæ have been assigned to protein; that of Mulder is $C_{36}H_{27}O_{12}N_4$; but its existence as a distinct proximate principle is doubtful.

Protest (Lat. protestor, *I bear witness*). In Parliamentary Law, a privilege peculiar to the members of the upper house of parliament, of entering (by leave of the house always presumed) their dissent from a motion or resolution agreed to by a majority of the house, together with their reasons for dissenting. The paper embodying these reasons of dissent is called a

protest, and is entered on the journals. Protests, with the reasons, were first set down, according to Lord Clarendon, in 1641. [PARLIAMENT.]

Protestants. A general name applied to the various denominations of Christians which have sprung from the adoption of the principles of the Reformation in the sixteenth century. The term was assumed, in the first instance, by the reformers of North Germany, who, in the year 1529, formally protested against a decree of the imperial diet held at Spires, which ordained that the question between the parties should remain unsettled, some restrictions being laid upon the progress of the new opinions, until the calling of a general council, the time of which was left uncertain. The Protestants accordingly asserted that the decree was unfavourable and unjust to their party, and claimed the immediate summons of a lawful council, which they knew it was the interest of the papacy, under the circumstances, to delay. In the early period of the Reformation, the principal reformed churches were two, those of the followers of Luther and of Calvin, the partisans of Zuingli having become nearly identified with the latter. Since that time the number of subdivisions upon every point of doctrine and discipline has been infinite. The general bond of union, however, among all, continues to this day to be the assertion of private judgment, and the rejection of any infallible head of the church, or ultimate authority in pope or council. In modern Christendom, there are three principal divisions of Protestants: Anglicans, or of the church of England; Lutherans (North Germany, Scandinavia); Calvinists (Holland, Switzerland, France, Scotland). A rough calculation would make their relative numbers in Europe about fourteen, thirty, and twenty millions, the latter including some classes of dissenters in England.

Proteus (Gr.). In the *Odyssey*, this mythical being is described as an old man who tends the flocks (seals) of Poseidon, and rises at midday from the depths, to sleep upon the shore, surrounded by the monsters of the sea. His abode is variously placed in Pharos and Carpathos. Anyone wishing to learn his secrets might do so by catching him during his slumbers and holding him fast until he had exhausted his powers of transformation. A later version of the Trojan war represents him as taking Helen from PARIS, and leaving to him in her place a phantom which he carried to Ilion. Herodotus, rationalising this version, accepts it as the true account of the matter. [OANNES.]

PROTEUS. In Zoology, this name was originally and very aptly applied to a genus of Infusoria, which, during life, never for a single minute maintain the same form; this peculiarity is strikingly manifested in the common species called *Proteus diffluens*. The term was subsequently used by Laurenti to designate a singular amphibious reptile, peculiar to certain subterranean waters in Carniola, and which, like the American siren, retains the external gills, together with internal lungs or air-bags, throughout life.

Prothallus (a word coined from Gr. πρῶτος, *first*, and θαλλός, *a sprout*). In Botany, the term applied to distinguish the first results of the germination of the spore in the higher cryptogams, as ferns, adder's-tongues, horsetails, &c., in which the new plant springs from the impregnation of a cell in peculiar organs called *archegonia*.

Protheite or **Protherite.** A variety of Idocrase from Zillerthal in the Tyrol.

Prothorax (Gr. πρό, *before*, and θώραξ, *a breastplate*). In Entomology, this word signifies the first segment of the thorax in insects; by Kirby the term is restricted to the upper part only, or shield of that segment.

Prothyrum (Gr. πρόθυρον). In Architecture, a porch before the outer door of a house.

Protocol (from the Latin protocollum: a word made up from the Greek πρῶτος, *first*, and κόλλα, *glue*). The word *protocol*, in the French language, signifies the formulæ or technical words of legal instruments; in Germany it has been used to denote the minutes or rough draught of an instrument or transaction. In this latter sense the word has been borrowed by diplomacy, in which it signifies the original copy of any despatch, treaty, or other document.

Protogine. A porphyritic rock in which mica is replaced by talc or steatite. The granite of Mont Blanc is of this kind, and much of the Cornish china clay is obtained from the decomposition of similar varieties of porphyritic rock.

Protomorphic (Gr. πρῶτος, and μορφή, *shape*). The first stage of organised beings intervening between the fecundation of the germ and the first appearance of the typical or characteristic organisation of the species.

Protonotary (Low Lat. proto-notarius, or *first notary*). A title originally of the Byzantine empire. The apostolical protonotaries of the papal court are officers having precedence of the other notaries or secretaries of the Roman chancery; the papal *notaries participant* rank after bishops, but before abbots. In England, certain officers in the Courts of King's Bench and Common Pleas formerly had this title, but the offices are now abolished.

Protoplasm (Gr. πρῶτος, and πλάσμα, *a formed work*). In Vegetable Physiology, the term applied to matter deposited over the inside walls of a plant-cell subsequent to the formation of the cell itself.

Protopteri (Gr. πρῶτος, and πτερόν, *a feather*). An order of fishes in which the endoskeleton is partly osseous and partly cartilaginous; the exoskeleton as cycloid scales; pectorals and ventrals as flexible filaments; gills filamentary, free; no pancreas; swim-bladder as a double lung, with an air-duct; intestine with a spiral valve. The *Protopterus* or *Lepidosiren* forms an example of the order.

Protosaurus (Gr. πρῶτος, and σαῦρος, *a lizard*). The first fossil Saurian discovered,

and described by Spener in the year 1710, from the copper slates of Thuringia. The original specimen is now in the Royal College of Surgeons' Museum. It indicates the existence, during the period of the Permian strata, of a large, probably aquatic reptile, with a powerful neck and head, and sharpened teeth which enabled it to seize and overcome the struggles of the active fishes of the waters which deposited the old Thuringian *Kupferschiefer*.

Prototype (Gr. πρωτότυπος, *after the first form*). In the Fine Arts, the original pattern or model of a thing whereon are founded principles of imitation.

Protozoa (Gr. πρῶτος, and ζῶον, *animal*). A name synonymous with *Acrita* and *Oozoa*, and applied to the simplest living beings, or those which stand, as it were, on the first step of organisation.

Protractor (Lat. protraho, *I draw forth*). A mathematical instrument for laying down angles on paper, used in surveying, plotting, &c.

In its simplest form, the protractor consists merely of a semicircular limb of metal, divided into 180°, and subtended by a diameter, in the middle of which is a notch to mark the position of the centre. On placing this notch over the angular point, and laying the diameter along a given straight line, an angle of any number of degrees may be made by marking the point on the paper which coincides with the given degree on the limb, and joining this point with the centre, when the instrument is removed. The protractor is rendered more commodious by transferring the divisions to the edge of a parallel ruler.

For plotting surveys on a large scale a more accurate form of protractor is employed (Simms *On Mathematical Instruments*); the principle, however, is the same in all.

Proustite or **Light Red Ruby Silver-ore.** A sulpharsenide of sulphide of silver; composed, when pure, of 19·4 per cent. of sulphur, 15·2 arsenic, and 65·4 silver. It is a valuable ore of silver, and is found in Saxony, Bohemia, Spain, Mexico, Peru, &c. Named after J. L. Proust, the French chemist.

Provençal Language. The language of the TROUBADOURS—one of the Romance dialects which sprang up on the decline of the literary Latin. For the relation of the Provençal to other cognate dialects, see LANGUAGE.

Provençal Poetry. [TROUBADOURS; TROUVÈRES.]

Proverb (Lat. proverbium). A familiar saying, which has been variously defined. In point of form, there are two species of proverbs; one containing a maxim directly expressed in a concise and familiar style; the other, in which a maxim is expressed metaphorically, e.g. *honesty is the best policy*, or rather allegorically, e.g. *strike while the iron is hot*. In point of substance, proverbs are for the most part rules of moral, or, still more properly, of prudential, conduct.

In dramatic literature, chiefly French, the term has been applied to short pieces, in which some proverb or popular saying is taken as the foundation of the plot. They originated in the fondness of the higher classes of France for private theatricals, which became a sort of passion about the middle of the last century. Carmantelli was the most successful writer of proverbs at the time of their highest popularity. Those of M. Théodore Leclercq, at the present time, have met with considerable success.

Proverbs of Solomon, The. One of the canonical books of the Old Testament. According to the arrangement in its present shape, the first nine chapters form a species of introduction; those from the tenth to the twenty-fourth contain the proverbs ascribed to Solomon; and the remainder furnishes a kind of appendix; including the thirtieth and thirty-first, which contain the proverbs ascribed to Agur, the son of Jakeh, and to King Lemuel. According to Mr. Aldis Wright (Smith's *Dictionary of the Bible* s.v.) it is probable that the portion immediately following ch. xxii. contains a collection made by the learned men of the court of Hezekiah.

Provincia. Those countries were called by the Romans *provinces*, which, having been reduced under their power, were subjected to government by magistrates sent from Rome. The laws of a province were generally settled by ten commissioners, despatched from Rome in conjunction with the victorious general. In its modern acceptation, the term *province* signifies a grand division of a kingdom or state, comprising several cities, towns, &c., all under the same government, and usually distinguished by the extent either of the civil or ecclesiastical jurisdiction; in the latter case, the province, being a union of several dioceses, is subject to the archbishop.

Provision (Lat. provisio, *a foreseeing*). In Ecclesiastical Law (but not in use in England), the supply of an incumbent to a clerical office: consisting of *designation* and *collation*.

Provisions. In the Army. *Daily*: At home—¾ lb. meat, 1 lb. *best seconds* bread in barracks, or 1¼ lb. in camp. The stoppage paid by the soldier for this home ration is 4½*d*. a day. Abroad—1 lb. bread, or ¾ lb. biscuit, 1 lb. of meat, fresh or salt; at some stations special rations are issued for sanitary reasons connected with the climate; during active operations the officer commanding may increase the bread ration to 1½ lb. bread, or 1 lb. biscuit, and may issue wine or spirits.

The stoppage for a foreign ration is 3½*d*. daily. The families of soldiers abroad receive fractions of rations: wife, ½; child under 7, ¼; from 7 to 14, ½ ration.

The provision of forage consists daily of 10 lbs. oats, 12 lbs. hay, and 8 lbs. straw for each horse: issued to the soldiers without stoppage, but to the officers subject to a stoppage of 8½*d*. per ration.

From these arrangements it will be perceived that the sailor (who has equal pay) is materi-

ally better off than the soldier. The former is supplied gratuitously with all his provisions, while the latter receives a portion of them, having to make a small but covering payment for the rest, while he has also to provide other articles of diet from the remainder of his pay.

PROVISIONS. In the Navy. *Daily*: 1¼ lb. of biscuit or 1½ lb. of soft bread; spirits, ⅛ of a pint; sugar, 2 oz.; chocolate, 1 oz.; tea, ¼ oz.; when procurable, fresh meat, 1 lb., and fresh vegetables, ½ lb. When fresh provisions cannot be procured: salt pork, 1 lb. with split peas, ⅛ of a pint; or salt beef 1 lb. with flour 9 oz., suet ¾ oz., and currants or raisins 1½ oz. *Weekly*: oatmeal, ¼ pint; mustard, ½ oz.; pepper, ¼ oz.; vinegar, ¼ pint. These are all issued to the sailor free, i.e. without any stoppage from his pay.

PROVISIONS. In Prisons and Workhouses. The dietary tables of workhouses are generally uniform. At the present time, those of the metropolis are divided into several classes, which are provisioned at different rates. Thus the allowance of able-bodied paupers is generally 12 oz. of bread, 1½ pint of gruel, 1½ pint of soup or broth every day; the females having the same allowance as the males, except that two ounces less bread is served to them. Three times a week they have 5 oz. of cooked meat and ½ lb. of potatoes at dinner; on three other days, as stated before, 1½ pint of soup; and on one day 14 and 12 oz. of pudding respectively. When broth is not served at supper, they have 2 oz. of cheese instead. Aged persons have the same allowances, except that an ounce of butter and a pint of tea are supplied daily instead of the gruel, cheese, and broth of the able-bodied inmates. Children are supplied according to their age; the youngest, i.e. under two years, having bread and butter at discretion, and a pint of milk, 3 oz. of meat, and ½ lb. of potatoes daily. The amount increases as they grow older, and when they reach nine years they are generally rated as able-bodied women. Suckling women are allowed 3 oz. more meat on days when meat is served, but are otherwise treated as able-bodied women. Casual paupers are generally allowed 6 oz. of bread. When the paupers are employed in the service of the parish, and are therefore partially earning their support, their allowances are increased. The meat served is, of course, exclusive of bones.

A prison dietary is generally constructed on a progressive scale, the allowances for *short times* being much scantier than those served for longer periods of imprisonment. Thus the diet of a prisoner confined for seven days is a pint of gruel for breakfast and another for supper, and a pound of bread for dinner. A slight variation, but no material addition, is made for terms not exceeding twenty-one days, while those who exceed twenty-one days get small allowances of soup and meat thrice a week; those committed for longer periods still, get meat four times a week, and cocoa for breakfast and supper. The dietary for long terms is a little in excess of that served to paupers, both in quality and quantity. Criminals who commit prison offences are put on the sparest diet.

Proviso. In Law, a qualifying clause inserted in an instrument, commencing usually with the words *provided that*.

Provisors, Statutes of. Several statutes passed in the reigns of Edward I., Edward III. and Richard II. (35 Edw. I., 25 Edw. III., 27 Edw. III., 38 Edw. III., 3 Rich. II., 7 Rich. II. &c.) for the purpose of checking the claims of the popes to present to bishoprics and livings in England.

Provisory. In Politics and Jurisprudence, an agreement, law, or institution, is said to be provisory, which, established or entered into on account of immediate wants, requires further completeness of sanction to render it permanent, and subsists only *provided* it is so sanctioned.

Provost (contracted from Lat. præpositus, *placed over*). The title of the chief municipal magistrates of Scotland, equivalent to *mayor* in England. The chief magistrates of Edinburgh and Glasgow are styled *lord provost*. This title also belongs to the heads of some colleges in the English universities.

Provost Marshal. In the Army, an officer appointed in camp to preserve good order and discipline, to take charge of prisoners, and prevent crime. He is intrusted with authority to inflict *summary* punishment on any soldier or individual connected with the army, whom he may detect in the actual commission of any offence against order and discipline.

Provost of a University. [UNIVERSITY.]

Prow (Fr. proue, Lat. prora). The fore part of a ship, generally; and, in particular, the pointed beak or cutwater.

Proxenus (Gr. πρόξενος). In the ancient Greek states, a citizen who was intrusted with or took upon himself the charge of guarding the interests of the citizens of a foreign state, was called in the former case a πρόξενος, in the latter ἐθελοπρόξενος. The relation, however, was at first wholly voluntary, having arisen from the hospitium privatum or private ties of friendship between citizens of foreign states connected with each other. But when in two states, between which public hospitality had been established, no citizens came forward voluntarily to fill the office, then some one was formally appointed to it by the state. The early Spartan custom was to send a Spartan to the foreign state, to see to the interests of his countrymen, like the modern consuls; but generally the proxeni were citizens of the state to which the stranger came. Thus Alcibiades was the Spartan proxenus at Athens. The duty of the proxenus was chiefly to entertain ambassadors, and to mediate in any disputes which might arise between his own townsmen and the strangers for whom he acted as proxenus. [PROSTATES.]

Proximate Principles. Distinct compounds which exist ready formed in animals and vegetables, such as albumen, gelatin, fat,

&c. in the former; and sugar, gum, starch, resins, &c. in the latter, which are so called without reference to their ultimate composition.

Proxy (Lat. proximus). In Parliamentary Law, every peer, spiritual or temporal, can (by license, supposed to be obtained from the king) constitute another lord of parliament, of the same order with himself, his proxy, to vote for him in his absence. Proxies cannot be used when the house is in committee, nor in any judicial causes, nor can a proxy sign a protest. By an order of 2 Ch. II. (May, *Parliamentary Practice*, ch. xii.) no peer can hold more than two proxies. [PARLIAMENT.]

Prud'homme (Lat. homo prudens). In France, during the middle ages, municipal tribunals composed of citizens exercising a sort of conciliatory or equitable jurisdiction, as arbiters of disputes, inspectors of police, &c., were termed councils of *prud'hommes*. In 1806, a court of this denomination was re-established at Lyons by a law of Napoleon; and several others have since been created. Their principal office is the decision of disputes between masters and workmen in manufacturing towns.

Prune. [PRUNUS.]

Pruning (this word is connected by Mr. Wedgwood with the Old Norse prjon, the Scottish preen, or prin, *a pin* or *knitting needle*, from the notion of picking or arranging nicely with a pointed implement: *Dictionary of English Etymology*). In Arboriculture and Gardening, the art of cutting off parts of plants, and more especially of trees and shrubs, in order to strengthen those which remain, or to bring the tree or plant into some particular form calculated to increase particular products. Pruning therefore varies according to the kind of plant or tree to be pruned, and according to the object in view.

In the case of forest trees, the general object of pruning is to increase the quantity of timber in the trunk by diminishing the side branches, commencing at the lower part of the tree when it is quite young, and gradually advancing upwards as the tree increases in growth. In the case of hedges, the object is to produce a dense mass from the ground upwards, which is effected by shortening the side branches.

In pruning trees which are cultivated for the sake of their fruit or blossoms, the object is to thin out the branches so as to admit the light and air more freely to their leaves and blossoms, and to concentrate and increase the nourishment for the branches which remain. In the case of trees, or shrubs cultivated for the beauty of their shapes, whether natural or artificial, the object of pruning is to deprive the trees or shrubs of all those branches which deviate from or interfere with the natural shape, or with the form which is intended to be produced by art. In pruning with a view to produce fruit, it is necessary to know on what branches and buds the fruit is produced. In some trees, as in the peach, it is generally produced on the wood of the preceding year; in others, as in the apple and pear, it is generally produced on wood of two years' growth; and in the vine it is produced on shoots of the current year. The general effect of pruning on plants is to increase their longevity; since the tendency of all vegetables is to exhaust themselves, and, consequently, to shorten their duration, by the production of seeds. In the operation of pruning, the shoots are cut off close to the buds, or at a distance from them not greater than the diameter of the branch to be cut off; because, without the near proximity of a bud, the wounds will not heal over. In shoots which produce their buds alternately, the cut is made at the back of the bud, sloping from it, so that it may be readily covered by bark in the same or in the following year. This is readily done with a pruning knife, by a slanting cut, made at an angle of 45° with the direction of the branch; but, in the case of branches where the buds are produced opposite each other, either one bud must be sacrificed, or the branch must be cut off at right angles to its line of direction. Root pruning consists in shortening the principal roots so as to check over-exuberance of growth, and induce fruitfulness. It is practised chiefly with fruit-trees and ornamental flowering plants. The operation of pruning may in many cases be superseded by rubbing off, or pinching out, the leaf-buds, so as to prevent superfluous shoots from being produced.

Pruning Knife. A knife the blade of which has a straight edge, formed of well-tempered steel, and of no great breadth, with a narrow point, in order that it may be more readily introduced among crowded branches. Formerly, pruning knives were hooked at the point; but the cuts made by such knives had a tendency to crush the shoot, and leave a rough section, more readily injured by the air and water, and less likely to be speedily healed over. Such knives, when of a large size, were called *pruning hooks*.

Pruning Shears. Shears in which one of the blades moves on a pivot working in an oblong instead of a circular opening; by which means a draw cut is produced similar to that effected by a knife, instead of the crushing cut produced by common shears, which fractures the section left on the branch, and renders it liable to become diseased or to decay, instead of being covered over with fresh bark. Pruning shears are particularly adapted for cutting spiny or prickly shrubs, such as the different species of thorns, gooseberries, or roses.

Prunnerite. A calcareous Tufa, of a greyish-violet colour, found in Faroe.

Prunus (Lat. *a plum-tree*). A genus of *Drupaceæ* which includes, with the common Sloe and Bullace of our hedges, the apricot and plum trees of our gardens; though the apricot is sometimes referred to the genus *Armeniaca*. [APRICOT.] The sloe or blackthorn is a shrub whose upright stems are sought after for walking sticks, whose leaves are used to adulterate

tea, and whose fruit is employed in the manufacture of fictitious port wine. The Plum is a well-known and highly esteemed fruit, of which many varieties are grown. Some are employed for preserves, and for making the prunes of the shops. The prunes which come from Brignoles, in the South of France, are prepared from a variety called the *Perdrigon*. The neighbourhood of Tours is celebrated for the quantity of prunes which it furnishes. The German prunes are prepared from an oblong purple variety called Zwetsche, a Slavonian name which is spelt variously on the Continent. Damsons are plums well known and much used in this country for preserving, and so are the small round nearly wild sorts called *bullaces*. *P. myrobolana*, the Cherry Plum, which is a Canadian species, bears medium-sized heart-shaped fruit, in great abundance, and of tolerably good quality, but it is not equal to the European varieties.

Prurigo (Lat. *an itching*). An itching of the skin with or without the eruption of small pimples. The term is also carelessly applied to irritation of various parts of the body from other causes, as from vermin, worms, &c.

Prussian Blue. This pigment was accidentally discovered by Diesbach, a colour-maker at Berlin, in the year 1710. It is largely consumed in the decorative arts, and in dyeing, and calico-printing: it is used in making some of the varieties of what is called *stone-blue*, and is sometimes added to starch, though for this purpose, as well as for covering the yellow tint of paper, smalt or cobalt blue is preferable. Prussian blue is prepared of different degrees of purity, by precipitating solutions of peroxide of iron by ferrocyanide of potassium, various additions being made according to the purposes for which it is required.

Pure Prussian blue is obtained by adding a solution of ferrocyanide of potassium to persulphate of iron, thoroughly washing the precipitate, first with water slightly acidulated by sulphuric acid, and then with pure water, and ultimately drying it in a warm place. Prussian blue is of a peculiarly rich and intense blue, with a copper tint upon its surface: it is insipid, inodorous, insoluble in water, in alcohol, and in dilute acids, and is not poisonous. The alkalies decompose it into soluble ferrocyanides and oxide of iron; hence, as a dyeing material, it does not resist the action of soap. According to Chevreul, Prussian blue becomes white in the direct rays of the sun, but regains its blue colour in the dark. It is occasionally used in the composition of writing fluids.

Prussian blue is regarded as a compound of cyanogen and iron, but various views have been taken of its atomic constitution, as it has been considered to contain, or not to contain, the elements of water. When anhydrous, it contains seven atoms of iron and nine of cyanogen; or four atoms of iron and three of ferrocyanogen; but it is generally admitted that it cannot practically be obtained in this state, and that it always contains water, or the elements of water, which cannot be expelled without decomposing the compound; if so, it is probably a hydroferrocyanate of the sesquioxide of iron.

Commercial Prussian blue is generally contaminated with alumina, and often with chalk, plaster of Paris, and starch. *Turnbull's Prussian blue*, which is of a singularly brilliant tint, is the precipitate obtained by adding a solution of ferrocyanide of potassium to a solution of protosulphate of iron. When a solution of perchloride of iron is poured into one of ferrocyanide of potassium the precipitate which falls is insoluble in saline solutions, but after having been washed so as to deprive it of adherent salts, is soluble in pure water: it is known as *soluble Prussian blue*.

Prussic Acid. The composition and chemical characters of this acid are given under the head of HYDROCYANIC ACID. Prussic acid is frequently used medicinally as a powerful sedative and anti-irritant, especially to allay cough in phthisis, and to mitigate the spasmodic action in hooping-cough; but from its poisonous nature it requires to be employed with much caution. The antidotes for prussic acid, where it has been taken as a poison, are solution of chlorine, by which it is chemically decomposed; and ammonia, which combines with it, and acts as a stimulant. [CYANOGEN; HYDROCYANIC ACID.]

Prytanæum (Gr. πρυτανεῖον). The place of assembly of the Prytanes. In a Greek city the Prytanæum was the home of the community, and answered to the private homes of individual citizens. Hence a fire was always kept burning in the Prytanæum as on the hearths of private houses. In this building were entertained those citizens who by virtue of their office or for merit received the privilege of having their meals at the public cost. At Athens this was among the highest honours which could be conferred on anyone. Hence Socrates, when asked to adjudge his own penalty, named this as the recompense due for his past life and teaching.

Prytanes (Gr. πρυτάνεις). The Athenian senate consisted of 500 persons, fifty being elected from each of the ten tribes; each of these fifties took it by turn to preside with the title of Prytanes, having one-tenth of the year assigned to it; or, more accurately speaking, 34 days were allotted to each of the first four tribes, and 35 to the last six; the Attic year consisting of 354 days. Each fifty was again subdivided into five bodies of ten, which, when prytanes, took it by turns to perform the duties of proedri (πρόεδροι), seven days being allotted each. From these proedri, again, was chosen by lot an epistates (ἐπιστάτης) or president, whose office lasted one day.

Przibramite. Cadmiferous sulphide of Zinc from Przibram in Bohemia. The name has also been given to the capillary variety of Göthite, which is met with at the same locality.

Psalm (Gr. ψαλμός, from ψάλλω, *I sing*). A sacred song or hymn, originally accompanied with music. The book of Psalms is called, in

the modern Hebrew, *Thehillim* (*praises*). It is popularly ascribed to King David, by whom it may have been partly collected and to some extent composed. The Jews divide it into five books, ending with Psalm xli. lxxii. lxxxix. cvi. and cl. respectively. They, as well as all Christians, retain the number 150; but the divisions have varied. An apocryphal 151st is added in some Greek versions. The 119th and following Psalms to the 134th, called by some *gradual psalms*, or *psalms of the stairs*, a term of which various explanations have been given, are thought by Calmet and others to have been composed on the occasion of the deliverance from Babylon; possibly by Esdras, who is considered as the first collector of the Psalms; but they were at least partially used before, as early as the reign of Hezekiah. An attempt has been made to determine the respective ages of a large number of the Psalms by their employment of the names Elohim and Jehovah. (Bishop Colenso *On the Pentateuch* and *Book of Joshua*; Bishop Harold Browne, *The Elohistic Psalms*.) The latest Psalms, according to views now prevalent, are subsequent to the Babylonish captivity, and celebrate the rebuilding of Jerusalem.

Psalter. A book of devotion containing the psalms. (Palmer's *Origines Liturgicæ*, vol. i. p. 207.)

Psalterium (Lat.). The name of the manyplies or third cavity of the complex stomach of the ruminant quadrupeds, so called because it is occupied by numerous broad folds of membrane resembling the leaves of a book.

Psaltery (Gr. ψαλτήριον). A stringed instrument in use among the ancient Jews, by whom it was called NABLUM. It resembled, according to Burney, partly the lyre and partly the harp.

Psaturose (Gr. ψαθυρός, *fragile*). A sulphantimonite of silver, composed, when pure, of 70·36 per cent. silver, 14·01 antimony, and 15·63 sulphur. It is of a dark lead-grey colour inclining to iron-black, and is found at Schemnitz in Hungary, Freiberg in Saxony, and Zacatecas in Mexico. [STEPHANITE.]

Psellismus (Gr. ψελλισμός, *a stammering*). An imperfect articulation. Stuttering.

Psephoi (Gr.). A general name given to several things made use of by the Greeks in giving their suffrages, and in their computations, as small stones, shells, beans, &c. They were synonymous with the CALCULI of the Romans.

Pseudæsthesia (Gr. ψευδής, *false*, and αἴσθησις, *perception*). Imaginary or false feeling.

Pseudepigraphy (Gr. ψευδεπίγραφος, *with false inscription*). The ascription of false names of authors to works. This practice was carried to a great extent among the Christians of the earliest centuries. (Mackay, *The Tübingen School and its Antecedents*, part iii. 25.) Thus, many of the verses known by the name of Sibylline are evident Christian forgeries; and it is extremely difficult to distinguish the spurious works of the Fathers from the true. (See Gieseler, *Textbook of Eccl. Hist.*, 1st period, chap. iii. sec. 52, for a good section on Christian pseudepigraphy; Fabricii *Codex Pseudepigraphus*; Barbier, *Dict. des Ouvrages Anonymes et Pseudonymes*, contains a notice of most works falsely ascribed to their alleged authors in the French language.)

Pseudo-bulb. In Botany, an enlarged aërial stem, resembling a tuber, from which it scarcely differs, except in being formed above ground in the epidermis, being often extremely hard, and in retaining upon its surface the scars of leaves that it once bore.

Pseudoblepsis (Gr. ψευδής, and βλέπω, *I see*). There are various forms of false vision, some apparently dependent upon nervous irritation, others upon organic derangement. Specks, network, colours, and imaginary bodies floating or dancing before the eyes, distorted vision, double vision, are among the most common modifications of this complaint. They occur in plethoric as well as in debilitated habits, and are the consequence occasionally of intense study, of weakening evacuations, of debauchery, of hysteria, and of hypochondriasis: the treatment, therefore, which is required is very various. Attention to the stomach and bowels, local bleeding, camphor, ether, and other nervine stimulants, change of scene and occupation, varied exercise, are among the efficient remedies. When this condition is brought about by organic disease of the brain, the treatment must vary according to the nature of the lesion. In such cases, however, there is generally little hope of recovery.

Pseudodipteral (Gr. ψευδής, and δίπτερος, *with two wings*). In Architecture, a building in which the distance from each side of the cell to the columns on their flanks is equal to two intercolumniations; the intermediate range of columns which would stand between the outer range and the cell being omitted.

Pseudomalachite. Native phosphate of copper. [PHOSPHOROCHALCITE; PRASINE.]

Pseudomorphous Crystals (Gr. ψευδής, and μορφή, *form*). Substances found in crystalline forms not belonging to them, and being, as it were, casts of other crystals.

Pseudonym (Gr. ψευδώνυμος, *falsely named*). In Literature, a false or imaginary name assumed by a writer; more strictly, however, the former. Those who only assume a fanciful name, e. g. *Junius*, being more commonly ranked with *anonymous* writers.

Pseudopods (Gr. ψευδής; πούς, *foot*). A name applied to a tribe of Polygastric Infusoria (comprising Amœba and its allies), including those in which the body, by various contractions and changes of form, produces pediform processes.

Pseudoscope (Gr. ψευδής, and σκοπέω, *I view*). A name given by Professor Wheatstone to the stereoscope when employed to produce what he calls *conversions of relief*. These conversions may be produced in three different ways: (1) by transposing the pictures from one

to the other; (2) by reflecting each picture separately, without transposition; and (3) by inverting the pictures to each eye separately. The converse figure differs from the normal figure in this circumstance, that those points which appear most distant in the latter are the nearest in the former, and vice versâ. The *pseudoscope* consists of two reflecting prisms placed in a frame, with adjustments, so that when applied to the eyes each eye may separately see the reflected image of the projection which usually falls on that eye. The instrument being directed to an object, and so adjusted that the object shall appear of its proper size, and at its usual distance, the distances of all other objects are inverted; all nearer objects appear more distant, and all more distant objects nearer, and this constitutes the *conversion of relief*. The inside of a teacup appears a solid convex body. A china vase ornamented with coloured flowers in relief, appears to be a vertical section of the interior of the vase, with painted hollow impressions of the flowers. A small terrestrial globe appears a concave hemisphere; when the globe is turned on its axis, the appearance and disappearance of different portions of the map on its concave surface has a very singular effect. A bust regarded in front becomes a deep hollow mask. When regarded in profile the appearance is equally striking. A framed picture hung against a wall appears as if embedded in a cavity made in the wall. (*Athenæum* for 24 Jan. 1852.) [STEREOSCOPE.]

Pseudoscorpions. A family of Arachnidans, including those with an oblong body divided into several segments, with two or four eyes, and six or eight legs, as the book-crabs. (*Chelifer*.)

Pseudothyron (Gr. ψευδόθυρον). In Ancient Architecture, a false door.

Psidium. An extensive genus of South American trees belonging to the order *Myrtaceæ*. The most important species is the Guava-tree, *P. Guaiava*, which produces the well-known Guava fruits of tropical countries, a small tree, seldom growing more than fifteen or twenty feet in height. Several varieties are known, the two most common, distinguished by the shape of the fruit—*P. pomiferum*, with a round apple-shaped fruit, and *P. pyriferum*, with pear-shaped fruit—being sometimes described as distinct species. Both are natives of tropical America and the West Indies, whence they have been introduced into and become naturalised in India and other Eastern countries. They also produce very good fruit in our hothouses. Their fruits have a thin bright-yellow rind, and are filled with a pulpy yellowish or red flesh, which has a pleasantly acid-sweet flavour; but the pear-shaped variety is sweeter and more agreeable in a raw state than the apple-shaped, though both make very good jelly or preserve. Guavas are of too perishable a nature to permit of their being brought to this country in their natural state; but considerable quantities of guava-jelly and guava-cheese are brought by the West-India mail steamers. The wood of the Guava-tree has a fine close grain. *P. Cattleyanum*, the Purple Guava, probably a native of Brazil, yields abundantly deep claret-coloured fruit having a pale juicy flesh which is agreeably subacid.

Psilanthropists (Gr. ψιλός, *mere*, and ἄνθρωπος, *man*). A name sometimes used to denote those who believe that Jesus Christ was an ordinary man, and the son of Mary and Joseph.

Psilomelane (Gr. ψιλός, *bare*, hence *smooth*; μέλας, *black*; from its smooth or botryoidal form and black colour). A common ore of manganese, of very variable composition, probably only a mixture of the proto-peroxide Mn_3O_4, with pyrolusite MnO_4, and usually a little potash, baryta, and water. The principal British localities are Restormel Royal Mine, Cornwall; Upton Pyne, Black Down, Ashton near Chudleigh, and near Bideford, Devonshire; Brendon Hill Mine, Somersetshire; Drygill, Cumberland; Hartshill, Warwickshire; Leadhill, Lanarkshire; Old Kilpatrick, Dumbartonshire; Braeborough (*coralloidal*), and the Orkneys.

Psittacines (Parrot tribe). The name of a tribe of Scansorial birds, of which the genus *Psittacus* is the type.

Psittacus (Lat.; Gr. ψίττακος). The parrots belonging to the restricted genus *Psittacus* commonly have a strong bill, the head large without crest, the face covered with feathers, the body thick, the tail short and square. The prevailing colour is green. The common grey parrot is the *Ps. erythacus*, a native of Africa, which has been known to breed in Europe.

Psoas Muscle (Gr. ψόαι, *the muscles of the loins*). A large muscle upon the fore part and sides of the lumbar vertebræ. It bends the thigh forwards, and assists in turning it outwards.

Psophia (Gr. ψοφέω, *I make a noise*). A subgenus of storks, having a shorter bill than the rest, with the head and neck covered only with a kind of down, and the circumference of the eye naked. They frequent wooded regions, and subsist on grains and fruits. The best known species (*Psophia crepitans*) is a native of South America, and is remarkable for the ambiguous sound which it emits from time to time, and from which its specific name is derived. This bird is easily tamed by the Spanish settlers in South America, and is even taught by them to defend the common poultry from the rapacious birds, as a shepherd's dog guards his sheep from the wolves.

Psora (Gr.). The itch. [ITCH; PRURIGO.]

Psoralea (Gr. ψωραλέος, *scurfy*). A large genus of Leguminous plants, very widely distributed, and consisting of small shrubby or perennial herbs, usually having pinnate leaves, and spicate or racemose flowers. *P. corylifolia*, an East Indian herb, bears pods which have an aromatic taste; they are employed medicinally by the native doctors in India, and also yield an oil. The pods, under the name of Bawchan-seeds,

have been sometimes sent to this country for pressing. *P. esculenta*, a native of North-West America, produces tuberous roots, known as Indian or Prairie turnips, which form a great part of the food of the indigenous population, but when boiled are rather insipid. In Chili the leaves of *P. glandulosa*, there called *Culen*, are used as a substitute for tea under the name of Jesuit's Tea; but their infusion appears to be valued more for its medicinal properties than as an agreeable beverage, being a powerful vermifuge and stomachic; an infusion of the root is emetic and purgative. The plant has been introduced into Mauritius, where it has acquired a reputation as a remedy for diseases of the respiratory organs.

Psoriasis (Gr.). A rough scaly state of cuticle, sometimes continuous and sometimes in patches, generally accompanied by chaps or fissures.

Psorophthalmia (Gr.). An inflammation and ulceration of the eyelids attended by an itching sensation.

Psyche (Gr. ψυχή, *breath* or *soul*). In the later Greek writers the word *psyche* occurs as a personification of the human soul: and probably Apuleius was thinking of this personification when he related the following tale.

By her surpassing beauty, Psyche, the daughter of a king, excited the anger and jealousy of Venus, who sent Amor (Love) to inspire her with a passion for the most contemptible of mortals. But Psyche so charmed Amor that he fell in love with her himself, and taking her to some secret cave, visited her nightly, leaving her always before the dawn. Psyche had been warned by Amor against all attempts to find out who he was; but her jealous sisters told her that her lover was a hideous monster, and Psyche determined to learn the truth. Taking a lamp, she gazed at her lover while he slept, and saw before her the most beautiful of the gods. Amor, waked up by a drop of oil which fell from the lamp, rebuked her for her mistrust, and vanished. Then began the sorrows and wanderings of Psyche, who sought Amor in every temple till she came to that of Venus, who put her to a series of toilsome and degrading tasks, under which she must have died but for the love of Amor, who, though invisible, still consoled and cheered her. By his help she at last pacified the wrath of Venus, and, becoming immortal, was united with her lover for ever.

An examination of this tale reveals the fact that it was not invented by Apuleius, and that the several incidents which characterise it reappear in many Teutonic legends as well as in Hindu fairy tales. [VENUS.]

Psychology (Gr. ψυχή, *the soul*; and λόγος). In its larger acceptation, this word may be taken as synonymous with mental philosophy; but it is frequently used in reference to the lower faculties of the mind, and the classification of the phenomena which they present. All psychology is built on experience, either immediate or revived by the memory and imagination. But, in reflecting on our intellectual faculties, we discover in them certain laws, which, as soon as they are presented to us, we at once recognise as universal and necessary; certain conditions without the fulfilment of which we are sensible that no act of intellection could have taken place. This universality is something very different from the empirical truth, as a matter of fact, which we attribute to the laws of association, which are, indeed, universal, but which might, for aught we can see, have been different from what they are. Corresponding to this distinction, German writers have discriminated between a higher, or rational, and a lower, or empirical psychology; the first, that of Kant, who sought, in all our mental faculties, to determine that only which is necessary and immutable; the second, that of Hartley, who treats all our intellectual acts as alike objects of mere history, dependent for their validity only on the fact that they do really recur in such and such order. The psychology of Aristotle was of the latter description. He consequently regarded the science as forming one of the physical sciences, or those which are conversant with the contingent and changeable. Many pregnant psychological truths are discoverable in that philosopher's work on the soul; in particular, the doctrine of association owes its first enunciation to him. Among later writers who have made valuable contributions to the science may be enumerated Hobbes, Locke, Hartley, Sir Thomas Brown, Lord Mackintosh, and Professor A. Bain. [ASSOCIATION.] For earlier psychological theories, see Hallam, *Literary History*, part iii. ch. iii. [METAPHYSICS.]

Psychomancy (Gr. ψυχόμαντις, *a necromancer*). A species of divination, in which the dead were supposed to appear as spirits, to communicate the wished-for information.

Psychotria (a word coined from Gr. ψυχή, *life*, and ἰατρεία, *healing*). A Cinchonaceous shrub of tropical countries, one, of which, *P. emetica*, a native of Peru, yields what is called *Striated Ipecacuanha*. It is inferior to true Ipecacuanha, but a useful substitute for it.

Psychrometer. [HYGROMETER.]

Ptah. [PHTHAH.]

Pteris (Gr.). The genus of the common Brake or Bracken, a fern which is chiefly remarkable as being distributed in one form or other nearly over the whole world. This plant is the *Pteris aquilina* of botanists, and bears several other names in different countries. The rhizomes are sometimes cooked and eaten. They have the curious character when cut through obliquely of showing a figure resembling a spread eagle, or in some positions an oak-tree. The Bracken is a very useful plant for packing purposes, as well as for thatch and litter.

Pterocarpus (Gr. πτερόν, *a wing*, and καρπός, *fruit*). A family of large-growing trees, belonging to the Leguminous order, and yielding Kino and one sort of Rosewood. They

have pinnate leaves, and showy yellow blossoms, succeeded by flat nearly round or oval and somewhat one-sided pods. Gum Kino is obtained in India from *P. Marsupium*, and in Africa from *P. erinaceus*. Both are large trees, affording valuable hard timber, that of the former being extensively used in India in the manufacture of cotton-gins, while that of the latter is known in Western Africa as Rosewood. Kino is obtained by making incisions in the bark, from which the juice exudes and hardens into a brittle mass, easily broken into little angular shining fragments of a bright ruby colour. It is used in India for dyeing and tanning. Another species, *P. santalinus*, yields the deep red dyewood known as Red Saunders, large quantities of which are annually exported from India. Kino is also used medicinally as an astringent.

Pterodactyle (Gr. πτερόν, *a feather*, and δάκτυλος, *a digit*). The name of a genus of extinct reptiles, in which the second digit of the hand is of extreme length, and is considered to have supported an aliform expansion of the skin. It is divided into three subgenera, *Rampho-rhynchus*, *Dimorphodon*, and *Pterodactylus*.

Pterodon (Gr. πτερόν, and ὀδούς, *a tooth*). A genus of carnassial Mammalia which has been found in the eocene strata in France. The analogies of the *Pterodon dasyuroïdes* have led many palæontologists to ascribe it to the Sarcophagous family of Marsupials, near *Thylacinus*, but it exhibits strong traces of affinity to the typical miocene carnivore, *Hyænodon*.

Pteropods (Gr. πτερόν, and πούς, *a foot*). The name of a class of Molluscs, comprehending those which have a natatory wing-shaped expansion on each side of the head and neck.

Pterosauria (Gr. πτερόν, and σαῦρος, *lizard*). An extinct order of reptiles, characterised by the pectoral limbs being adapted for flight, through elongation of the antibrachium and fifth digit; by the pneumaticity of the skeleton; procœlian vertebræ; and a head large, with long dentigerous jaws. The principal genera of this order are given under PTERODACTYLE.

Pterygians (Gr. πτέρυξ, *a wing*). A name applied by Latreille to a group of Molluscs, corresponding to the Cephalopods and Pteropods of Cuvier, both of which have locomotive organs composed of wing-like expansions of the skin.

Pterygoda (Gr. πτέρυξ). Latreille has given this term to two small, hard, movable bodies, in the form of little elytra, directed backwards, and terminating at the origin of the wings. They arise from the two sides of the anterior extremity of the trunk, near the exterior base of the two first legs, instead of from the second segment of the trunk, like true elytra. They are present in Lepidopterous and Strepsipterous insects.

Pterygoid (Gr. πτερυγώδης, *wing-shaped*). This name is applied to processes of the sphenoid bone, which complete the osseous palate behind, and form distinct bones in the oviparous vertebrate animals.

Ptisan (Gr. πτισάνη, *barley-water*). A medicated drink prepared in France from the flowers of *Malva sylvestris*. It is also called Tisane.

Ptolemaic System. The astronomical systems of the Greek philosophers were based for the most part on theories for the truth of which no attempt was made to adduce the evidence of facts. But although they had thus a speculative character, they aided (sometimes not insensibly) the progress of a real science, as requiring the observation of phenomena in support of their several hypotheses.

The Pythagorean doctrine (the life and date of Pythagoras himself are shrouded in doubt and obscurity) asserted that the earth is not motionless in the centre of the universe, but that the central place is occupied by a mass of fire, which was mysteriously called the Altar of Nature and the Mother of the Gods. Round this centre, ten bodies moved in circular orbits, in the following order:, at the highest extremity the heaven containing the fixed stars, next the five planets, then the sun, then the moon, then the earth, and after the earth the ANTICHTHON. (Sir G. C. Lewis, *Astronomy of the Ancients*, 124.)

The first systematic explanation of the periodic motions of the planets came from Eudoxus of Cnidos (406–350 B.C.), who asserted that they were held in solid revolving spheres. This hypothesis of revolving spheres, which had been simple and intelligible enough while confined to the movement of the fixed stars, was made still more intricate by Calippus (a contemporary of Aristotle), who added seven spheres to the twenty-six of Eudoxus. With Aristotle as with Plato the earth was fixed at the centre of the universe, which, like Eudoxus, he held to be composed of revolving spheres, the motion of the bodies placed in these spheres being measured by their distance from the centre. But Aristotle saw that the motions of some of the planets were more intricate than those of the sun and moon, which he believed to be more distant from the external sphere. The solution of this difficulty he found in the conscious life of the stars, owing to which 'each orb accomplishes its circuit according to the best means at its command.' From the gravitation of matter to a centre he inferred the sphericity of the earth; and the comparative smallness of its size he gathered from the fact, that a slight change of distance to north or south changes the position of the fixed stars in those directions. His system was, in fact, substantially that which, under the name of Ptolemy, maintained its ground until it was finally set aside by the system of Copernicus. It was supported by the logic of Euclid, and in Galen's day the demonstration was as thoroughly believed as that two and two make four.

Against this system one remarkable protest was made by Aristarchus of Samos, who proposed a theory of the world exactly similar to that of Copernicus. [HELIOCENTRIC SYSTEM.] The date of Aristarchus is fixed by the testi-

mony of Ptolemy, who states him to have observed the summer solstice of the year 280 B.C. His theory is known to us only from secondary sources; but among these is the testimony of Archimedes, who could not fail to understand the hypothesis and to report it correctly. Archimedes was born 287 B.C.; and the theory of Aristarchus may have been published after he had reached his manhood. (Sir G. C. Lewis, *Astronomy of the Ancients*, 190.) From Archimedes, who rejected the theory, we learn that Aristarchus believed the earth to revolve in a circle, of which the sun was the immovable centre, the fixed stars being also motionless; that he assigned to the earth a rotation on its own axis; and that he explained the apparent annual motion of the sun in the ecliptic, by supposing the orbit of the earth to be inclined to its axis. (*Edinburgh Review*, July 1862, p. 94.)

The Alexandrian school of astronomy is pre-eminently distinguished by the names of Eratosthenes, Apollonius, Hipparchus and Ptolemy. Between the two latter there intervened a period of nearly 300 years, during which the practical astronomy of the Greeks made little progress. Hipparchus observed at Rhodes about 140 years B.C. This illustrious man appears to have paid little regard to the theoretical speculations of his contemporaries, but adopted the only method by which a correct knowledge of nature can be obtained, namely, assiduous and accurate observations. Among his important discoveries are the precession of the equinoxes; the length of the solar year; the eccentricity of the earth's orbit; the periodic time of the moon's revolution with respect to the stars, to the sun, to her nodes, and her apogee; the eccentricity and inclination of the lunar orbit. He invented the planisphere, determined the places of 1,080 stars, and was the first who introduced into geography the method of fixing the positions of places on the surface of the earth by means of their latitudes and longitudes.

The name of Ptolemy is still more celebrated than that of Hipparchus, although, as an astronomer, he occupies a far inferior rank. His principal astronomical discovery is the inequality of the moon's motion, technically called the *evection*; but his fame chiefly rests on his great work called *Syntax*, or *Composition*; in which he explains the apparent motions of the sun, moon, and planets, according to a hypothesis invented by Apollonius of Perga some centuries before, and which consists in supposing each of these bodies to be carried by a uniform motion round the circumference of a circle called the *epicycle*, the centre of which is carried uniformly forward in the circumference of another circle called the *deferent*. This second circle may be the epicycle of a third, and so on as long as inequalities remained to be explained; the earth occupying a position near, but not at, the centre of the last circle. This hypothesis is utterly demolished by a few accurate observations of the present day; but in the time of Ptolemy it served to explain all the deviations from circular motion then known, particularly the phenomena of the stations and retrogradations of the planets; and it was even of service to astronomy, by offering a means of reducing the apparent irregularities of the planetary motions to arithmetical calculation. Ptolemy's share of the merit belonging to the invention of this ingenious hypothesis consists in the determination of the proportion between the radius of the epicycle and that of its deferent circle, and between the velocity of the planet and the velocity of the centre of its epicycle. The Ptolemaic system continued in vogue till the revival of astronomy and the other sciences in the fifteenth century, when it gave place to theories founded on more enlarged views and more accurate observations.

Fourteen centuries elapsed between Ptolemy and Copernicus; and during this long interval astronomy continued nearly in the same state. The elements of the solar and lunar tables had indeed received many corrections; and various improvements in the methods of observing and calculating had been introduced, principally by the Arabs; but in respect of theory, no change had taken place. But an epoch had now arrived when men's minds could no longer be held in thraldom by reverence for ancient authority; and a spirit of investigation and enquiry had arisen, which produced the happiest results in all the departments of natural science. Copernicus, guided perhaps in some measure by the opinions of Pythagoras, but more by his own meditations on the planetary phenomena, and the comparison of the numerous observations accumulated by Purbach, Regiomontanus, and Walther, in the latter half of the fifteenth century, had the glory of establishing the system of the world on its true basis. In his great work, *De Revolutionibus Orbium Cœlestium*, published in 1543, he showed that all the apparent motions are easily explained by simply attributing a double motion to the earth; a diurnal rotation about its axis, and an annual motion about the sun. The doctrine of the earth's motion was opposed to the religious dogmas of the age, and accordingly the theory of Copernicus met with great resistance; but as observations now began to be greatly multiplied, and to be performed with greater accuracy, the evidences in favour of it daily acquired strength, and in a short time commanded universal assent among astronomers. Tycho Brahe, indeed, an excellent observer, and one to whom astronomy is under the greatest obligations, made an attempt to save the ancient prejudices; while he explained the phenomena by supposing the sun, accompanied by the planets, to perform a diurnal revolution about the earth. This system, however, on account of its physical improbability, never obtained many followers.

The next important step in astronomy was made by Kepler. By means of a laborious comparison and calculation of observations, Kepler discovered that the orbits of the planets

are not circles but ellipses, having the sun in one of the foci. He also found that the motion of any planet in its elliptic orbit is so regulated that the spaces passed over by a straight line drawn from the planet to the sun are equal in equal times; and that the periodic times of the different planets are in a certain given ratio to their distances from the sun. It is difficult to estimate the importance of these discoveries, either with reference to the amount of prejudice they overthrew, or their influence on astronomical theory. The circular and uniform motion of the celestial bodies was an axiom that had never been disputed. It was even admitted by Copernicus, who was obliged, in order to reconcile it with the observations, to suppose the sun placed at a little distance from the centre of each of the planetary circles. The elliptic motion was a proposition as bold as it was original; and, combined with the equal description of areas in equal times, led to the discovery of universal gravitation, and all the *sublime* results of physical astronomy.

Ptolemaites. A sect among the Gnostics, who maintained that the Mosaic Law came partly from God, partly from Moses, and partly from the traditions of the Jewish doctors.

Ptyalin (Gr. πτύαλον, *saliva*). A supposed peculiar animal matter obtained from saliva. It is insoluble in alcohol, and is said to be analogous to the vegetable substance termed *diastase*, and to convert starch into dextrine and glucose; it has therefore been termed *salivary diastase*. [SALIVA.]

Ptyalism (Gr. πτυαλισμός). An increased flow of saliva. Salivation.

Ptychotis (a word coined from Gr. πτυχή, *a fold*, and οὖς, *an ear*). An Umbelliferous genus of annual or biennial plants, one species of which, *P. Ajowan*, is much cultivated in Bengal, where its fruits, called *Ajowains*, are valued for their aromatic properties, and are used both for culinary and medicinal purposes.

Pubescent (Lat. pubescens, *hairy*). In Botany and Zoology, when a part or whole is covered with very fine short hairs.

Public Safety, Committee of. In the first French Revolution, this famous body, formed out of the Convention, April 6, 1793, was invested with very general powers to provide for the supposed welfare of the state, even the power of arrest and imprisonment being soon conferred upon it. After the downfall of the Girondist party [GIRONDISTS], this committee became the virtual government of France, by a decree of Dec. 4, 1793. Its members were, at this period, elected every month, but in general the members were re-elected. From this period its history is, in effect, that of the revolution. It appointed tribunals, composed of committees, invested with sovereign power to try offences against the state, over the whole country. It was in the committee of public safety that the opposition to Robespierre originated; but, on the overthrow of that personage, its powers were limited by the Convention; and, on the introduction of the new constitution of October, 1794, it became extinct along with the Assembly out of which it had been formed.

Public Schools. [SCHOOLS, PUBLIC.]

Public Weal, War of the. In French History, this name has been given to that struggle between the feudal aristocracy and the monarchy, which was ended by the defeat of the confederation entitled the League of the Public Weal, by Louis XI. The great feudal chiefs, especially of the houses of Foix, Albret, and Armagnac, saw with dislike and fear the growth of an absolute power in which they could have no share; but although the alliance into which they entered was nominally based on the interests of the people, and professed to redress their injuries, it had little or no popular support. It had become clear to the French that only under a strong government could they be secured against the violence of military ruffians and the lawless exactions of feudal chieftains. This discontent of the nobles came to a head, when the dukes of Brittany, Burgundy, Alençon, Bourbon, and the count of Dunois, leagued themselves under Charles duke of Berry, brother of Louis XI. and heir presumptive to the throne. But Louis contrived to prevent the interference of Edward IV. of England; the duke of Berry died suddenly at Guienne, not without suspicion that he had been poisoned by the king, and the less powerful vassals were rigorously punished, and the league finally crushed in 1472. (Hallam, *Middle Ages*, ch. i. part i.)

Publicans (Lat. publicani). The farmers of the public revenue of Rome. They formed two distinct classes: the farmers-general of the revenues, who were regarded as belonging to one of the most honourable grades of citizens; and deputies or under publicans of an inferior caste, whose reputation was very questionable. Hence, in the New Testament, the τελῶναι, or *publicans*, are almost always placed in juxtaposition with sinners. (Milman's *Hist. of Christianity*.) This term was also applied as a nickname to the ALBIGENSES.

Publicist. A term sometimes applied to writers on International Law.

Publilian Laws. In the ancient history of Rome, the name of three laws said to have been enacted by the dictator Q. Publilius Philo, B.C. 339. By the first of these laws the decrees of the plebs were to bind the whole community. By the second the senate was bound to give a preliminary consent to all laws put to the vote in the comitia of centuries. The third provided that one at least of the censors should be a plebeian. For the historical difficulties involved in the various accounts of these enactments, and of the earlier Publilian agitation assigned to the year 470 B.C., see Sir G. C. Lewis, *Credibility of Early Roman History*, ch. xii. sect. 32 and ch. xiii. sect. 22.

Pucha-pat. An Indian name for Patchouli. [POGOSTEMON.]

Puck (Old Norse puki, Welsh pwca: Wedgwood. Dr. Latham says that the Slavonic word bog, *deity*—whence the English

bogy—is 'almost certainly the same word as Puck; perhaps the root of *Bacchus*.' The connection of *bogy* with *bug* is attested by the expression *bug-bear*, to denote that which scares or terrifies). In Mediæval Mythology, the 'merry wanderer of the night,' whose character and attributes are depicted in Shakspeare's *Midsummer Night's Dream*. This celebrated fairy is known by a variety of names; as *Robin Good-fellow* and *Friar Rush* in England; and in Germany, as *Knecht Ruprecht*; but it is by his designation of Puck that he is most generally known both in England, Germany, and the more northern nations. He was the chief of the domestic tribe of fairies, or *brownies*, as they are called in Scotland; and innumerable stories are told of his nocturnal exploits, among which drawing the wine and cleaning the kitchen while the family were asleep, are the most prominent.

Pudding Stone. A name sometimes given to a peculiar variety of Conglomerate consisting of pebbles, rounded by the action of water, cemented together with a large quantity of silicious paste. Masses of such conglomerate are common in Hertfordshire. The pebbles within them bear a fanciful resemblance to the raisins in a plum pudding, but the stones are generally much larger than raisins.

Puddling. The method resorted to in iron works for the conversion of cast into wrought iron. It consists of two operations, the first being designed for the purpose of allowing the impurities of the iron to escape in the course of the refining process, while the second, which is the more correctly named process of *puddling*, consists in reducing the cast iron to the state in which it is susceptible of being drawn, hammered, and rolled into the shape of bars in the state of wrought iron.

Puerperal Fever (from Lat. puerpera). A fever attended by peritoneal inflammation, which comes on about the third day after delivery. The usual febrile symptoms are attended with great tenseness and tenderness of the abdomen; the milk disappears, and the bowels are usually affected by diarrhœa. It is most common in the autumn, and appears to be contagious. It is an alarming disease, and requires great promptitude and judgment in its treatment. It must be regarded as the result of contamination of the blood by animal poison generated in the system, and not as a local affection. This poison is probably produced by the decomposition of coagula or other material retained in the uterus. Bleeding, modified according to the circumstances of the case, calomel, saline sudorifics, and occasionally opium, to quiet pain and induce rest, are among the remedial means; but it often happens that great irritability of the stomach and bowels, or even incessant purging and vomiting, are predominant symptoms, and the fever assumes a typhoid character, in which case the system requires support from cordials.

Puffball. [LYCOPERDON.]

Pufflerite. The name given to the globular Prehnite of the Seisseralp in the Tyrol.

Pugging. In Building operations, the word *pugging* is used to denote the coat of lime and hair, or chopped straw, laid upon the sound boarding, in order to resist the transmission of sound between one story and another.

Pugil (Lat. pugillus). A quantity of anything which may be taken up between the thumb and two fingers.

Pugmill. A mill used by brickmakers for the purpose of thoroughly blending the materials. It is an upright cylinder, in the axis of which a shaft revolves having several knives projecting from it, arranged spirally round the arbor, so as effectually to knead and mix the mass of clay, which is finally forced through a hole in the bottom of the cylinder.

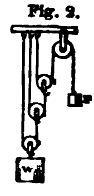
Puisne Judge (Nor. Fr. puisné, *younger*). The judges and barons of the Queen's Bench, Common Pleas, and Exchequer, with the exception of the chief justices and chief baron, are so called.

Pulley. In Mechanics, one of the six simple machines, or mechanical powers. It consists of a wheel, movable about an axis, and having a groove cut in its circumference, over which a cord passes. The axle is supported by a box or sheave, called the *block*, which may be either movable or fixed to a firm support.

Fig. 1.

A single pulley serves merely to change the direction of motion; but several of them may be combined in various ways, by which a mechanical advantage or *purchase* is gained, greater or less, according to their number and the mode of combination. The purchase gained by any combination is readily computed by comparing the celerity of the weight raised with that of the moving power, according to the principle of virtual velocities, which is alike applicable to all machines of whatever kind. In fig. 1, which represents a system where the several portions of the cord are parallel to each other, suppose the weight W to rise 1 inch, the two blocks would approach each other by that quantity, and consequently the length of cord connecting a single pair of pulleys would be shortened by 2 inches, so that the power P would descend 2 inches. Let the number of pulleys in each block be n; then, while the weight ascends 1 inch, the power descends $2n$ inches, and, consequently, when there is equilibrium, the power is to the weight as 1 to $2n$.

Fig. 2.



In the combination represented in fig. 2, the purchase is much greater. If n be the number of pulleys, it is readily seen that the relative velocities of P and W are as 2^n to 1, so that the power is to the weight as $1 : 2^n$.

In the combination represented by fig. 3, the mechanical advantage with n pulleys is still greater, and is easily proved to be as 1 to

$2^{n+1}-1$. This theoretical advantage, however, is in all cases greatly diminished by friction and the rigidity of the rope.

The last two combinations are of little, if any, use in practice, but various modifications of the first are common. *Smeaton's pulley*, or *Smeaton's tack*, as it is usually called, contains two rows of wheels, one under the other, in each block, and a single cord is made to pass over them in such a manner that the power and the weight both act in the same line with the centres of the two blocks, so that there is no tendency to twist. But this ingenious arrangement is open to several objections, the chief being the great amount of lateral friction of so many independent wheels. In White's pulley (fig. 1) the wheels in each block turn on the same axis, and consequently revolve in the same time; and they are of different sizes, their dimensions being so proportioned that a point on the circumference of any wheel moves with the velocity of the rope on that wheel. To effect this the diameter of the wheels in the upper block must be as the numbers 1, 3, 5, &c., and in the lower as 2, 4, 6, &c. Instead of separate wheels, the upper and lower blocks are cut in grooves in the above proportions, whereby the friction is reduced to that of one wheel in each block.

Fig. 2.

In the Great Exhibition at South Kensington, in the year 1862, an ingenious application of the system of pulleys was exhibited under the name of *Weston's patent pulley block*, which dealt with weights of from two to three tons, with the motive power of only one man. The sheaves of the blocks in this machine revolved in such a way as to offer a resistance to the motion of the rope, or chain, in case the power were suddenly withdrawn, so that the weight would remain suspended; and it required no hoisting crab, which is a serious drawback to the ordinary pulley blocks. There was no difference, however, in the principles regulating the arrangement or the sizes of the details of this machine from the principles generally observed.

Pulmogrades (Lat. pulmo, *a lung*; gradior, *I advance*). The name of a tribe of Acalephans, including those gelatinous species which swim by the contraction of the vascular margin of the disc-shaped body, where respiration also probably takes place.

Pulmonaria (Lat. pulmo). A genus of perennial herbs, often met with in old gardens, and remarkable for the spotted leaves of some of the species, from which cause, and some reputed but wholly imaginary value in lung diseases, it was called Lungwort. It is also called Jerusalem Cowslip.

Pulmonaries. The name of the order of Arachnidans including those which breathe by means of pulmonary sacs or lungs.

Pulmonates. The name of an order of Gastropodous Molluscs, including those which breathe air, to which the blood is exposed while circulating through a vascular network lining the internal surface of the bronchial cavity.

The order is subdivided into the *Pulmonata terrestris*, comprehending the Linnæan genera *Limax* and *Helix*, with *Clausilia*, Drap., and *Achatina*, Lam.; and the *Pulmonata aquatica*, comprehending the genera *Onchidium*, Buchanan; *Planorbis*, Cuv.; *Limnæus*, Lam.; *Physa*, Drap.; *Auricula*, Lam.; *Conovulus*, Lam.

Pulp (Lat. pulpa). In Botany, the juicy tissue found in the interior of plants. The term is applied in an especial sense to such tissue in fruits.

Pulpit (Lat. pulpitum). In Architecture, the raised part in a public building from which an oration is delivered. In the ancient theatres it was the higher part of the stage on which the musicians stood.

Pulque. The fermented juice of the *Agave*.

Pulse (Lat. pulsus, *a beating*). The pulsation of the arteries, depending upon the impulse given to the blood by the action of the heart. [Heart.] The pulse is usually felt by pressing the *radial artery* at the wrist, and the rapidity, regularity, and force of the circulation thus ascertained furnish an important criterion of the phenomena and progress of disease. The range of the pulse as to *frequency*, in a healthy adult, is usually between 60 and 80, but there are persons whose pulses rarely beat 60 times in a minute, and others, not out of health, in whom the frequency exceeds 80; the pulse, in short, is extremely capricious, and before any correct inferences can be drawn from it, the peculiarities of each individual require to be carefully considered. Slight mental affections, indigestion, irritability, and many other causes producing modifications of the pulse, do not admit of any general description. The terms *hard*, *full*, *soft*, and *wiry* pulse, are used to indicate other obvious modifications independent of the number of pulsations. The average rate of the pulse of a healthy infant is, for the first year, from about 120 to 108; for the second year, from 108 to 90; for the third, from 100 to 80; from the seventh to the twelfth year, the pulsations are about 70. When the pulse exceeds 140 beats in a minute, it is not easy to count it precisely, and to this it attains in some febrile diseases.

An *intermitting pulse* is by no means uncommon, and often produced by trivial causes: with many persons in perfect health the pulse will be subject to very extraordinary irregularities; and there are cases on record in which a person's pulse which has always intermitted in a state of health has acquired regularity on the accession of disease. The state of the digestive organs, more especially in gouty persons, has often a marked influence upon this condition of the pulse.

Pulse. Leguminous plants cultivated for their pods or seeds, such as the pea, bean, kidney-bean, &c.

Pulse Glass. A tube of about a quarter of an inch diameter and five or six inches long, with a bulb at each end, and about half filled with spirit of wine, care having been taken to expel the whole of the air before sealing the tube. When held in an inclined position, one of the bulbs being grasped in the hand, the ebullition of the included liquid causes the latter to rise and fall in the tube, or to *pulsate*.

Pulvilli (Lat.). In Entomology, the cushions of short hairs very closely set, or a membrane capable of being inflated, or very soft and concave plates, which cover the underside, or their apex, of the four first joints of the manus or tarsus, and sometimes even of the ends of the movable spines situated at the apex of the *tibia*, which act so as to produce a vacuum, and enable the insect to suspend itself, or walk against gravity.

Pulvinated (Lat. pulvinar, *a pillow*). In Architecture, a term used to express a swelling in any portion of an order, such, for instance, as that of the frieze in the modern Ionic order.

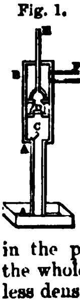
Pulvinus (Lat. *a cushion*). In Botany, the cushion-like enlargement seen at the base of the leaves, or at the apex of the petioles in certain plants.

Pumice (Lat. pumex). A porous rock obtained only in volcanic districts, and produced by the action of gases on materials melted by volcanic heat. It is light, spongy, and fibrous, of an ashy grey colour, and extremely rough to the touch. It is somewhat largely used in the arts, owing to its uniform roughness and the absence of irregularities of hardness. It can only be regarded as a variety of trachytic lava.

Pump (Ger. pumpe, Fr. pompe). A machine for raising water. Though the forms under which this useful engine is constructed, and the mode in which the power is applied, may be modified in an infinite number of ways, there are only four which can be considered as differing from each other in principle. These are the *sucking pump*, the *forcing pump*, the *lifting pump*, and the *centrifugal pump*: so called from the manner in which they act.

The *sucking pump*, or common household pump, is an apparatus of which the principle and construction will be evident from the annexed figure. A A is a pipe of any convenient length, the lower end of which reaches below the surface of the water in the well or reservoir; B is a barrel, generally of greater diameter than the pipe; C a valve opening upwards; D a piston moved by the rod E: in this piston there is also a valve opening upwards. When the piston is raised, the air in the barrel between the valves is expanded, and its tension consequently diminished; the pressure of the air in the pipe, therefore, opens the valve C, and the whole air in the pipe and barrel becomes less dense. In this state the atmospheric pressure on the surface of the water causes it to rise in the pipe, until the tension of the confined air becomes equal to the pressure of the atmosphere. On again depressing the piston, the valve in it opens, and the air passes through it from the barrel as it descends; but the valve C is closed by the downward pressure, and the volume of water which has entered the pipe remains. On again raising the piston, the same effect is repeated, and an additional quantity of water enters the pipe. Thus, by the alternating motion of the piston, a column of water is raised in the pipe until it reaches the piston when at the bottom of the barrel, and the whole of the air below it has been excluded. On raising the piston when the water has reached it, the fluid will be compelled to follow by the pressure of the atmosphere on its surface in the well. When the piston is again depressed, the water flows through the valve in it, and ascends into the barrel, and by the succeeding strokes of the piston is lifted up until it reaches and flows out of the spout F.

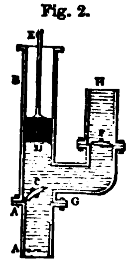
Fig. 1.



Although in theory the limit of the height to which water may be raised by the sucking pump, from the surface of the fluid in the well to the highest position of the movable piston, is about thirty-four feet (the height of a column of water which balances the pressure of the atmosphere), it is not found practicable, with pumps of the ordinary construction, to raise it more than about twenty-eight feet. The difference arises from the difficulty of making the apparatus absolutely air-tight.

The *forcing pump* is represented in fig. 2. The piston-rod E D is attached to a solid plunger D, adjusted to the cavity of the barrel. A pipe G H, furnished with a valve F, opening outwards, communicates with the barrel at G. On elevating the plunger D, the water will ascend through the valve C, in the same manner as in the sucking pump, till the barrel is filled to D. Now, when the plunger is depressed the valve C will shut, and the water between D and C be forced through the valve F into the pipe G H. When the plunger is raised, the valve at F shuts, the pressure on its under side being removed, so that the water which was forced into the pipe by the previous stroke cannot return into the barrel. At the next stroke of the piston more water is again forced into the pipe, and so on till it is raised to the height required.

Fig. 2.

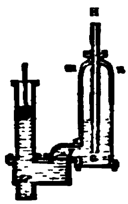


In this pump the pipe A A may be dispensed with, and the barrel B immersed in the reservoir; in which case the action of the pump is independent of the atmospheric pressure, and could be maintained equally well in a vacuum.

In order to produce a continued stream through the pipe G H, an air vessel *m n* may be attached to the lateral branch above the

valve F (fig. 3). The pipe G H reaches nearly to the bottom of the air vessel; and when the water has been forced into the vessel by the action of the pump, until it reaches above the lower end of the pipe at G, it is evident that, as all communication is then cut off with the external atmosphere, every additional quantity of water thrown into the vessel will tend more and more to compress the air within, which, acting by its pressure on the surface of the water, forces it through the pipe G H in a continued stream.

Fig. 3.



The *lifting pump* is represented by fig. 4. The barrel of the pump is immersed in the water and fixed to an immovable frame. The piston with its bucket and valve C, opening upwards, is attached at E to another frame, G H I K L, consisting of two strong iron rods, H I and L K, which move through holes in the frame-work to which the pump is fixed. An inclined branch M N, either fixed to the top of the barrel, or movable by means of a ball and socket, is fitted exactly to the barrel, and furnished with a valve at M. Suppose the barrel immersed in the water to a certain depth: if the piston frame be now thrust down by the handle at G, the piston will descend, and the water be forced by its upward pressure through the valve C, so as to maintain the same level in the pump as in the well. But when the piston frame is elevated, the valve C will shut (as shown in the figure), and the water above C be *lifted up* with the piston, and forced through the valve M into the branch M N, from which its return will be prevented by the shutting of the valve M when the piston descends.

Fig. 4.

In each of these different kinds of pumps which have been described, the total effort required to work the machine, independently of friction, is equal to the weight of a column of water, the base of which is equal to the area of a section of the working barrel, and the altitude equal to the distance between the surface of the water in the reservoir and the point to which it is raised. In the sucking pump the whole of this effort is expended in raising the piston; in the forcing pump, one part is expended in raising and the other in depressing the piston, and it is advantageous to dispose the machinery so that these two parts shall be nearly equal. In small pumps for domestic purposes, the strength of man is usually employed as the moving power; but in raising water from great depths, as the bottoms of mines, the steam engine is applied to this purpose. [Fire Engine.] For an account of the mechanism of different kinds of pumps, see Gregory's *Mechanics*, vol. ii.; the *Aide-Mémoire of the Military Sciences* may also be consulted, both for the bibliography and the description of the different kinds of pumps.

The *centrifugal* or rotary pumps are those in which a rectilineal vertical motion is communicated to the water to be raised by means of a wheel, bearing a series of fixed arms rotating at a high velocity in a close drum, and receiving its supply through apertures in the side of the drum close to the axis. The shape of the arms has a very material influence upon the useful effect of these pumps; and, after many experiments, it has been found that the most advantageous form to be given to them is to curve them backwards to the direction of the movement, so as to form a tangent to the circumference of the wheel at the points where they intersect it. Amongst the most valuable forms of these centrifugal pumps for drainage purposes, are those manufactured by Mr. Appold, or by Messrs. Gwynne & Co.; and perhaps it may be desirable to add that the latter work with the smallest loss of power compared to the useful effect, with small lifts: Appold's pumps, however, present more satisfactory results when higher lifts are required. All these engines are inferior to the best forms of force pumps when large volumes of water have to be raised to great heights; and their use would appear, in their present forms at least, to be most advantageously limited to lifts of about thirty or forty feet vertical as a maximum. (*English Cyclopædia, Arts and Sciences.*)

The *chain pump* sometimes used in ships of war consists of an endless chain moving over a wheel on the gun deck, which is turned round by winches, and over a roller in the pump-well, having saucers or flat circular pistons at certain intervals. Near the pump-well, on the side on which the chain on turning the winches ascends, are a few feet of pipe; through this the saucers raise the column of water, which, being lifted over the upper orifice of the pipe, falls into the cistern, and thence into the waste-pipe, called the *pump-dale*, which carries it overboard. The descending portion of chain falls through another case called the *back case*. Chain pumps, in large ships, throw out a ton a minute.

Pumpernickel. The name of a species of rye bread peculiar to Westphalia. It forms the chief food of the Westphalian peasants, but is regarded as a great delicacy in other parts of Germany, whither it is exported in large quantities. The loaves sometimes weigh 60 lbs. The term is said to be of French derivation, and to have originated in a French soldier having rejected the bread with disgust, exclaiming, 'C'est bon pour Nicolas:' i.e. for his horse.

Pumpkin. The *Cucurbita pepo*, a large kind of Gourd, cultivated as an esculent.

Pun. A play upon words, the wit or point of which depends on a resemblance between the sound of two or more words, which have different, and perhaps opposite, meanings. [Paronomasia.]

Punch (Ital. punzecchiare, *to punch*, from punzone, *a goad*). The process of producing a

hole in a piece of metal by direct pressure is called *punching*. This process can be applied only to the malleable metals, such as lead, zinc, copper, iron, &c., cast iron or bronze being liable to break or to produce a ragged edge, if so treated. The action of piercing the plates by means of a drill must not be confounded with punching.

Puncheon. In Architecture, a short post; also the small quarters of a partition, above the head of a door.

PUNCHEON. A measure of capacity for liquids, containing 84 gallons or one-third of a tun.

Punctate (Lat. punctum, *a point*). In Zoology, when a part is beset with many points or minute impressions, which do not perforate the surface.

Punctuation. In Printing and Writing, the dividing words, propositions, or sentences from each other by means of certain marks or points, designed to facilitate the apprehension, or to regulate the enunciation, of written language. Points or stops are said to have been first used by Aristophanes, the Alexandrian grammarian; but the modern system of punctuation is due to Aldo Manucci (Manutius), a learned printer, who lived at Venice in the fifteenth and sixteenth centuries. The marks most commonly in use are: 1. The comma (,), which is placed between the less important divisions of a sentence or passage; as, for instance, before and after qualifying propositions or clauses; between single words not connected by conjunctions; before conjunctions which unite sentences, &c. 2. The semicolon (;), which distinguishes the longer or more important members of a sentence; as when the latter part is an inference from, or qualification, explanation, or illustration of, the former. 3. The colon (:), which is chiefly used to distinguish such members of a sentence as are themselves divided by semicolons into two or more principal parts. 4. The period or full stop (.), which stands at the end of a complete sentence. Besides these may be enumerated the note of interrogation (?) or enquiry; of exclamation (!), expressing admiration, endearment, or any considerable emotion; the parenthesis ( ), used when a clause is inserted which interrupts the progress of the sentence; with other marks, either less commonly used, or for the use of which the rules are less easily defined.

Punctum Caecum (Lat.). That part of the retina of the eye immediately about the spot at which the optic nerve unites with it is found experimentally to be totally insensible to the stimulus of light, and hence it has been called by writers on Optics the *punctum cæcum*.

Pundit. [PANDIT.]

Punic Language. The language of the ancient Carthaginians. It was a Phœnician dialect, and substantially the same as the Hebrew.

Punic Wars. The name given to the celebrated contests in which the Romans and Carthaginians were engaged for more than three centuries, and which finally terminated in the destruction of Carthage. The first commenced A.C. 264, and ended A.C. 241; the second lasted from A.C. 218 to A.C. 202; the third from A.C. 149 to A.C. 147, ending with the destruction of Carthage.

Punic Wax. In Painting, the vehicle used by the Greek painters in their wax and encaustic pictures, &c. Punic wax, says Pliny (*cera Punica*), was the ordinary yellow wax purified and bleached, by being boiled three times in sea water with a little nitre, the water being changed each time: it was then taken out of the water, covered with a thin cloth, and placed in the sun to dry. So prepared it was mixed with various colours and made into *ceræ* fit for the painter's use, and it was also employed in varnishing or polishing.

Punica (Lat. punicus, *red*). The genus of the Pomegranate, which is called by botanists *P. granatum*. The fruit is peculiar, being composed of two whorls of carpels placed one above the other. It is the produce of a tree growing in Northern Africa and Western Asia, and varying from fifteen to twenty-five feet in height. The flowers are usually scarlet and yield a red dye. The fruit is greatly valued in warm countries on account of its cooling and refreshing pulp. Many varieties are grown, some being sweet and vinous, and others acid or of a bitter astringent taste. It is generally about the size of the fist, and has a tough leathery rind of a beautiful deep golden colour tinged with red. The rind, especially that of the bitter kind, contains a large quantity of tannin, and is used for tanning the celebrated morocco leather. Some double-flowered varieties are very beautiful garden shrubs.

Punicin. A peculiar principle having the appearance of an oleo-resin obtained from the root of the Pomegranate, *Punica granatum*.

Punishment (Lat. pœna, *punishment*). In Jurisprudence, the infliction of suffering, under legal sanction, upon those who have violated the law.

It is undoubtedly true, that both in legislation and in public opinion respecting punishment, the *vindictive* theory which considered it as a retribution for crime, and to be governed by our moral feelings of indignation against the offender, has far too generally prevailed, and that the primary end, the interests of society, has been overlooked. But it may perhaps be doubted whether the present course of opinion does not run too exclusively in the contrary direction, and whether they who adopt the common formula, that 'the object of all punishment is the prevention of the offence in future,' have reflected on all the consequences of that position.

For instance, it is the common practice in this country, as well as in others, to connect the administration of justice with the enforcement of the tenets of religion and morality. In passing sentence, wherever there is any peculiarity in the case calculated to call forth such remarks, the judge rarely fails to comment on

the moral deformity of the act; not merely in its tendency to injure society, but subjectively, as showing moral depravity in the person committing it. (Lord Russell, *The English Government and Constitution*, ch. xxiv. 1865.) The solemnities of public worship which form part of the ceremonial; the public harangues of the judges (as, for instance, in the English custom of charging the grand jury); the language in which the jury is commonly addressed, both by the judge and the advocates; all these seem based on the assumption, that the moral quality of acts is one of the matters to be brought under their consideration. But if the judge has really no concern whatever with that moral quality, and is simply there to see that society may be guarded, as far as possible, from exposure to material injury by fraud or violence, it may be thought that all these ceremonies are out of place, and that they can be defended only as politic devices, employing the machinery of religion to aid in deterring offenders from the commission of crime, or as concessions to popular ignorance. And it is certain that in such a case it would be far better to abolish them altogether, as leading the mind to dwell on that view of the object of punishment which it is the purpose of Bentham and his school to extirpate, as irrational and false.

Again, in popular estimation, the moral atrocity of an offence is one of the elements in the correct measure of punishment. On whatever ground philosophers may object to sanguinary laws, this conviction has retained its hold on the public mind. In the case of forgery, for example, the feeling of the majority triumphed in the end over the severity of the law, not so much because the penalty was thought disproportioned to the injury inflicted on society or to the importance of repressing the crime, as because it was thought not to deserve it in a moral point of view. Now all such expression of sentiment, on the theory in question, is founded on a wrong principle; and the writers who adhere to it are forced to admit this feeling as a disturbing cause, preventing the right doctrine from being fully carried out; they are forced to admit, as part of their definition of a good punishment, that it shall not be such as to shock the popular notion of moral justice —an admission which they can make consistently only by maintaining that punishments which shock popular notions of justice and equity are likely to multiply offences or aggravate their character, and so to interfere with the real interests of society.

That the interest of society is the first object of punishment must be conceded on all hands. That the specific object of preventing the offence from being committed is a very important part of that general object, probably by far the most important, may also be conceded. But it is a further question, whether the general object does not comprehend other particular objects also; and whether a punishment which should answer in the highest degree the advantage of repressing that particular offence, or class of offences, might not be imperfect notwithstanding.

This question can be solved only by deciding the great preliminary difficulty of political science, in which so many others are involved; whether the ruling power which we call the state, or society, or the legislature, has or has not any *moral* authority. Those who conclude that it has nothing to do beyond preserving the personal security and property of individuals, of course deny that it has any. But those who believe that it has, also, what may be termed paternal power, and is intrusted by Providence with the maintenance of religion and moral principle, must, consistently, admit that there may be a moral object in punishment beyond the mere prevention of the offence, unless they maintain that the moral authority of the state is to be exercised not in punishment but in prevention, as by education.

And it must be observed in passing, that those who do hold the state to possess such a moral authority, and have such moral duties imposed upon it, need not, therefore, hold those to be its principal objects. It may very well be that the primary object of the association of men in a political body is security and self-defence; yet that association may have other ends not inconsistent with this. And although those other ends are in themselves incomparably the most important, it does not at all follow that they are the most important as regards the state. When men enter into a particular contract with each other, their mutual duties under that contract are primarily those connected with the object of that contract; they may have other and more important mutual duties, which yet, as regards that contract, are secondary. No religious man will deny that the connection of master and servant involves some duties of a very exalted character; but the principal object of that connection is, nevertheless, the rendering of service in lieu of a remuneration.

It must, however, be remembered that the theory of the moral vocation of the state does not necessarily justify retribution as an object of punishment. No one can apportion retributive justice who cannot judge of the motives of actions. The moral authority of the state, even by those who have carried its divine character to the highest point, has only been likened to the paternal; and no father has the right to chastise a child by way of retribution. He has no right to punish at all, except with a view to reformation. Omitting this mistaken end, the real objects of punishment may be classed as follows:—

1. The interest of society; which must be subdivided into—

i. Its security from the injury to person or property occasioned by the crime.

ii. Its moral and religious improvement.

2. The reformation of the offender. This is admitted as one of the ends of punishment by all writers; but Bentham and his

followers regard it as such only so far as it conduces to the security of society by preventing the repetition of the offence; those who embrace the other view regard it as an end, both on this account and also as the fulfilment of the duty of the state towards the offender himself. Considered in either view, it is clearly a secondary object only, the good of society being the first.

The security of society is attained by punishment in four ways:

1. By forcibly preventing the offender from repeating his offence; as by death, mutilation, or perpetual imprisonment.

2. By reforming the habits of the offender, and thereby taking away the desire to offend.

3. By deterring the offender from repetition by the fear of fresh punishment.

4. By deterring others through example. And this last is clearly the chief practical end of all legal inflictions. The admission of other principles, in order to satisfy the idea of the existence of the state as a moral agent, need not prevent the legislator from keeping this steadily in view.

If Bentham's theory of punishment be defective in its main principles, it is so at all events only from being imperfect, not erroneous; as far as it goes, it is logical, consistent, and definite. And as he was nearly the first writer who introduced anything like clearness or arrangement into the popular notions on penal laws, so we are inclined to think that, on the whole, he has done more for society in this particular than in any other of the various subjects to which he applied his reforming genius. It must not be forgotten that Sir S. Romilly and Sir J. Mackintosh were the pupils who carried his speculation into practice.

Bentham divides punishments into corporeal and privative. The first of these are: 1. Simply afflictive, those which consist in the mere infliction of temporary pains, the lash, &c. 2. Complexly afflictive, in which pain is joined with permanent loss: as in the old punishments of mutilation and disfigurement. 3. Restrictive, under which he classes together imprisonment, or the total deprivation of liberty, and banishment, which deprives of a certain portion of liberty. 4. Active or laborious; such as the galleys, hard labour, &c. Transportation combines this character with the former. 5. Privative punishments, or those which deprive the criminal, 1. Of life. 2. Of reputation only; such, perhaps, as the amende in French law. 3. Of property: as by fine and confiscations. 4. Forfeiture of condition; which, more or less, accompanies infamous punishments in most countries: e.g. civil infamy, in France, is attended with various disabilities. These punishments comprehend all the simple forms in ordinary use; but he adds a few, which he terms anomalous, and only mentions them in order to hold them up to general reprobation. 1. What he calls *vicarious* punishments; as when the family of a suicide are punished by the forfeiture of his chattels. 2. Transitive; when the penalty passes to future generations; corruption of blood in the English law. 3. Collective; of which he gives, as an instance, the punishment of corporations for the acts of individual corporators; a more ordinary one is, the compelling the inhabitants of a hundred to make good the damages occasioned by a riot. 4. Fortuitous; where individuals wholly unconnected with the offender are implicated, as it were casually, in the consequences of his crime; of which he gives as an instance, the avoidance of mesne conveyances by some kinds of confiscation, and consequent loss of innocent purchasers; and the imposition of deodands, where no negligence is imputed. (Bentham, *Theory of Punishments and Rewards*; *Ed. Rev.* vol. xxii.; Lucas, *Système Pénal*; De Tocqueville, *Du Système Pénitentiaire aux États-Unis*; J. S. Mill, *On Liberty*, ch. iv.)

On the subject of capital punishment, opinions have of late years undergone considerable modification. The argument which based the infliction of such punishment on an alleged divine command, supposed to be contained in Genesis, has been tacitly, if not avowedly, abandoned, and the argument from expediency has been more prominently brought forward in its stead. The *Report of the Royal Commission on Capital Punishment*, 1866, recommends the substitution of private for public executions, and proposes to introduce a distinction between two varieties of crimes, now classed together as murder and capitally punishable. Of the commissioners, two were in favour of the immediate abolition of the death penalty. The gradual change in opinion on this subject is illustrated in Lord Russell's *Treatise on the English Government and Constitution*. In the first edition, published in 1825, Lord John Russell, while declaring that 'there cannot be many offences to which capital punishment ought to be attached,' asserted that 'all wilful acts tending directly to inflict death ought to be punished with death,' and added that, 'murder, stabbing, shooting at, burning of dwelling-houses or buildings contiguous to dwelling-houses, and setting fire to the clothes of a person, are crimes of this description.' In the introduction to the second edition, published in 1865, Lord Russell, while still he doubts not the right of a community to inflict such punishment, or the expediency of exercising that right in certain states of society, adds, 'When I turn from that abstract right and that abstract expediency to our own state of society, when I consider how difficult it is for any judge to separate the case which requires inflexible justice from that which admits the force of mitigatory circumstances, how invidious the task of the secretary of state in dispensing the mercy of the crown, how critical the comments made by the public, how soon the object of general horror becomes the theme of sympathy and pity, how narrow and how limited the example given by this condign and awful punishment, how brutal the scene of the execution, I come to the con-

clusion that nothing would be lost to justice, nothing lost in the preservation of innocent life, if the punishment of death were altogether abolished.'

Punneeria. An Indian genus of *Solanaceæ*, found in Scinde and Afghanistan. The berries of the only species, *P. coagulans*, a shrubby plant, growing from one to three feet high, are known to the natives as possessing the property of coagulating milk, in the same manner as rennet, for which they are substituted by the Beloochees and Afghans, who call them *punneer-bund*, i.e. cheesemaker.

Punt (Dutch pont, Fr. ponton). A small open pontoon, resembling a boat with a flat bottom and ordinarily with square ends. Though occasionally fitted for oars, the punt is in general propelled by poles acting on the bottom. It is useful for navigating shallow waters, as rivers, marshes, &c., or for any operation in which a steady base is desirable.

Pupa (Lat.). A genus of land snails, so called from the resemblance of the shell to the pupe, or chrysalis of an insect. Several species are British, as *Pupa umbilicata*, Drap.; *P. marginata*, Drap.; *P. edentula*, Drap.

Pupa (Lat. pupa). The name of the oviform nymphs of lepidopterous insects; also applied to metabolian insects generally, when in the second stage of their metamorphosis.

Pupil (Lat. pupilla). A term applied to the central opening of the eye, because it reflects the diminished image of the person who looks into it. It is the central aperture of the *iris*.

Pupil (Lat. pupillus). In Jurisprudence, properly, an infant or other under a *guardian*; popularly, a scholar under a teacher.

Pupipara (Lat. pupa, and pario, *I bring forth*). Those insects are said to be pupiparous which produce their young in the condition of a pupe or nymph; as the forest-fly, *Hippobosca equina*.

Pupivora (Lat. pupa, and voro, *I devour*). The name of a tribe of Hymenopterous insects, comprehending those of which the larvæ live parasitically in the interior of the larvæ and pupæ of other insects.

Purana (Sansc. *a poem*). The sacred books of India which contain the explanation of the Shaster. There are eighteen books of the Puranas; chiefly filled with legends of the inferior gods and the heroes of Hindustan. (*Mem. de l'Acad. des Inscr.* vol. xxxviii.) Much doubt is entertained as to the great antiquity of the Puranas. (Professor H. H. Wilson, translation of the *Vishnu Purana*, *Asiatic Journal*, Dec. 1840; Max Müller, *His. of Sansk. Lit.*)

Purbeck Beds. A compact shelly limestone or imperfect marble, alternating with clay and fossil limestones, resting on the Portland beds, and forming the uppermost group of the great series of the oolites in England. Among the beds are some which are called Dirt-beds; these seem to have been portions of an ancient vegetable soil. Others are marbles, used in churches and other buildings in some parts of England. Most of them are of fresh-water origin. The Purbeck beds are thin, but persistent, over a considerable space in the county of Dorsetshire; they are, however, very local, no exact representative appearing in the middle or north of England, and none on the Continent.

Above the dirt-beds of the Purbeck series are compact beds of oyster shells, known locally as the Cinder-bed, and others occasionally quarried for building-stone and slate. The well-known Purbeck marble, loaded with remains of *Paludina*, occurs in the upper parts of the series.

The lithological characters of the Purbeck beds, as well as their order of succession and the nature of their fossils, is shown in considerable detail in the published sections of the Geological Survey of Great Britain.

Purchase. In Law, generally the acquisition of lands or tenements by any other means than descent; as by devise, gift, or contract.

Purgatory (Lat. purgatorius, *cleansing*). A place appointed for the satisfaction of temporal punishments, which, according to the Roman Catholic church, are distinguished from the eternal, the latter only being remitted by the death of Christ. The doctrine of purgatory, which Augustine of Hippo mentions as a new opinion, was much discussed between the Greeks and Latins at the council of Ferrara, 1438. The present Roman Catholic belief is thus expressed in the creed of Pope Pius IV.: 'Constanter teneo purgatorium esse, animasque ibi detentas suffragio fidelium juvari.' To which it may be added, that the sins supposed to be punished in purgatory are of two kinds —mortal, but repented of; and venial. This article of the creed is derived from the canon of the council of Trent on the subject, sess. 25. The 'Romish doctrine' of purgatory is condemned by Art. 22 of the English church. The reader will find the general argument for purgatory well stated (among Protestants) by Hooker in his 3rd Sermon; the latter part, in which he replied to it, is lost. See also *Tracts for the Times*, No. 79.

Purification (Lat. purificatio, *a cleansing*). An observance enjoined on the Jews upon occasion of certain accidental deflements which are scrupulously recorded in the Levitical code. The purification was generally by water; and in the case of women, who were considered impure after childbirth for the space of forty days if delivered of a male, and eighty if of a female, the offering of a lamb or some other sacrifice was required. The purification of the Virgin Mary is a festival in the calendar, and is observed on February 2, being forty days after Christmas. This festival was established in the sixth century, and is variously termed in ecclesiastical antiquities by the names of Festum Candelarum, Candlemas, the Presentation. The processions of this day were instituted by Gregory the Great.

For an account of the ceremonies of purification among the Greeks and Romans, see Lustration.

Purim. The name of the solemn festival among the Jews in which they commemorate their deliverance from the wiles and stratagems of Haman, as recorded in the book of Esther. The observance of this festival has been religiously maintained by all the Hebrew race down to the present time. It is a movable feast.

Purism (Lat. purus, *pure*). Asceticism in taste; a preference for the emaciated and affected to the beautiful and natural. Overbeck may be considered as one of the most prominent of the Purists. [QUATTROCENTISMO; PRÆRAPHAELITE.]

Purist. A name sometimes applied to rigorous critics of purity in literary style.

Puritans. The name by which the dissenters from the church of England were generally known in the reign of Elizabeth and the first two Stuarts. The term was applied to them from the fact that they professed to follow the Word of God alone, purified from all human inventions and superstitions, of which they believed the English church to retain a considerable share, notwithstanding its alleged reformation. According to Fuller, the use of the name commenced about 1564. (Neale's *History of the Puritans.*) [DISSENTERS.]

Purlin. In Architecture, a piece of timber lying on the principal rafters of a roof, for the purpose of dividing the length of the bearing of the common rafters.

Purple (Gr. πορφύρα, Lat. purpura). In Painting, a colour produced by the mixture of red and blue, and thence partaking of the hue of each. Among the ancients, purple was always the distinguishing badge of power and distinction; and, of all the various kinds in use, the Tyrian dye is the most celebrated. This colour was produced from an animal juice found in a shell-fish called *murex*, or *conchylium*, the quality of which, however, varied with the different coasts on which it was caught. [MUREX.]

Purple of Cassius. A compound of the oxides of tin and gold, obtained by adding a mixture of protochloride and perchloride of tin to a solution of chloride of gold. It is used as a purple colour for porcelain painting, and also for staining glass, to which it imparts a fine ruby red.

Purple Copper-ore. A mineral of the composition $3\,Cu_2\,S+Fe_2\,S_3$ containing from 55 to 70 per cent. of copper. [ERUBESCITE.]

Purpura (Lat. *purple*). An eruption of small purple specks and patches, caused by extravasation of blood under the cuticle; it is attended by constitutional debility, and sometimes by fever. Aperient medicines, and occasional purgatives, carried to a greater or less extent, followed by mild tonics, and in some cases by wine, bark, and acids, are the principal remedies; but, in the treatment, much will depend upon the concomitant symptoms.

PURPURA. In Zoology, a generic name of the univalve Gastropod which secretes the purple fluid forming the base of the Tyrian dye. [MUREX.]

Purpure. *Purple.* In Heraldry, one of the colours or tinctures used in blazonry. It is equivalent to amethyst among precious stones, Mercury among planets. In engraving, it is represented by diagonal lines from the sinister to the dexter side of the escutcheon.

Purpuric Acid. A substance resulting from the action of nitric acid upon uric acid; it forms deep red or *purple* compounds with most bases. [MUREXIDE.]

Purpurifers (Lat. purpura, *purple*; fero, *I bear*). The name of a family of Gastropodous Molluscs, including those species which secrete the purple substance forming the celebrated dye of the ancients.

Purpurin. One of the colouring matters of madder; closely allied to alizarin.

Purree or **Indian Yellow.** A yellow colouring matter imported from India and China. Its origin has not been accurately ascertained, but it is supposed to be of animal origin, and to consist of a peculiar acid (*purreic* or *euxanthic acid*) combined with magnesia. [EUXANTHINE.]

Purse. A Turkish money of account containing 500 piastres, and worth on the average (for Turkish money is very debased) about 4*l.* 13*s.* 9*d.* sterling.

Purser (from *purse*, Fr. bourse, Ital. borsa, Gr. βύρσα). Formerly an officer in the British navy, whose chief duty consisted in keeping the accounts of the ship to which he belonged; but he also acted as purveyor. The title of this officer has been since 1844 PAYMASTER.

Pursuit, Curve of. The curve described by a point which pursues, with uniform velocity, another point which describes with a different, but still uniform, velocity a given right line not passing through the first point. The curve was first discussed by Bouguer in the *Mémoires de l'Académie*, 1732. It again came under discussion in consequence of a problem, respecting a dog following its master, which was proposed in the *Correspondance de l'École Polytechnique*, t. ii., and which was solved by St. Laurent in Gergonne's *Annales*, vol. xiii. The arcs of the curve are obviously proportional to the intercepts, on a fixed line, between the tangents at their extremities. Taking the fixed line as ordinate axis, the intercept upon it made by the tangent at (xy) will be $y-x\dfrac{dy}{dx}=y-px$. The increment of this, which is $-x\,dp$, being proportional to the increment of the arc, which is $ds=dx\sqrt{1+p^2}$, we have at once, for the differential equation of the second order,

$$x\,dp+\lambda\,dx\sqrt{1+p^2}=0,$$

where λ is the relative velocity of the two points. By integration we arrive at the equation of the curve, which contains two arbitrary constants a and b, and may be written in the form

$$2\,(y-b)=\frac{a}{\lambda+1}\,x^{\lambda+1}+\frac{a^{-1}}{\lambda-1}\,x^{-\lambda+1}.$$

The curve, therefore, is always algebraic ex-

cept when $\lambda = 1$, when a logarithmic term will enter into its equation.

Pursuivants. In Heraldry, a kind of probationers in the Heralds' College of England, not admitted to the full privileges of the college, but advanced by succession into its higher offices. They are styled *Portcullis*, *Rouge Dragon*, *Blue Mantle*, and *Rouge Croix*.

Purûravas. [URVASÎ.]

Purveyance (Fr. pourvoir, Lat. providere, *to provide*). Among the privileges possessed by the English monarchs down to the time of the Restoration, and the subsequent abolition of feudal incidents, was that which, known under the name of *purveyance*, entitled the officers of the household to take corn and cattle for the use of the king, and to employ beasts of burden for the carriage of the king's effects. As the monarch, like other great landowners or feudal lords, generally travelled from one manor or castle to another, accompanied by his retinue, and resided on the spot till the store was consumed, the infliction of purveyance was very general; and as the privilege, belonging originally only to the king and his family, was frequently usurped by his household, the burden was very severe. Moreover, as the payments were made in tallies on the exchequer, the prospect of such remuneration as the crown gave was very remote; and as the king bought in a larger measure than that fixed by the standard, the loss was large, as well as capricious in its incidence. Hence the statute book is full of enactments, limiting the number of persons who should possess the privilege, defining the measure by which the corn should be purchased, prescribing the occasions and times for impressing beasts of burden, and assuring the payment of the debts incurred. As, however, these statutes are constantly repeated, we may conclude that they were constantly broken, and we know from the rolls of Parliament that the grievance was felt to be intolerable. In order to evade these exactions bribes were freely given, and to large amounts, to the king's officers, either with a view of getting rid of the purveyance altogether, or with that of making the transaction as light as possible. The system, as far as regards purchases and impressments of cattle, was got rid of by stat. 12 Ch. II.

The only relic of purveyance which remains to the present day, is the right possessed by the crown, and exercised through the War Office, of billeting soldiers upon innkeepers, the ratio at which the soldier is to be lodged and boarded being fixed by the military authorities. In practice this exaction does not fall upon the metropolis or on such towns as have permanent barracks, and is perhaps not over-onerous in other places since the facilities of transit have been so considerably increased by railway communications. But in theory the system belongs to a bygone age, is partial in its incidence, and unjust in principle. It is possible that, while the billeting of soldiers on small public-houses may be no inconvenience to the owners, and even indirectly a source of profit, it may fall with undue severity on such inns as are constructed for the accommodation of the wealthier classes. Of course it is impossible for the innkeeper to house his involuntary guests, and he has to pay for their lodging elsewhere. This payment forms a tax upon his occupation, heavy because it affects some of the traders and not others, and because, if shifted at all, it is put upon those who make use of the inn, in enhanced rates for food and lodging.

Pus (Lat.). A bland yellowish fluid, somewhat like cream, found in abscesses, and formed upon the surfaces of what are termed healthy sores; it is heavier than water, and when viewed under the microscope appears composed of translucent globules floating in a colourless serum. The globules contain fatty matter and cholesterin. An albuminoid substance has also been found in pus, called *pyin*, soluble in water, but precipitated by acetic acid and by a solution of alum. Boedecker has announced the presence of leucin and of a peculiar crystallisable acid in pus, which he calls *chloridic* acid, and Forbes has obtained a blue compound (*pyocyanin*) from certain purulent secretions which are occasionally met with, and which leave a blue stain on linen.

Puschkinite. A green, yellow, or red variety of Epidote from Siberia.

Putamen (Lat.). In Botany, the inner coat, or shell, or stone of a fruit; commonly called the *endocarpium*.

Putchuk. One of the Eastern names applied to the roots of the Costus, *Aplotaxus Lappa*.

Putlog. In Architecture, short pieces of timber used in scaffolds, for supporting the scaffold boards. They are placed at right angles to the wall, one end of them resting on the ledges of the scaffold, and the other on holes left for them in the wall. In many of the ancient Roman buildings, as in the Pont du Gard, the holes thus left are treated as parts of the ornamentation of the building, under the name of *columbaria*, according to Vitruvius, from the supposed resemblance of the holes so left to the holes in a dove cote.

Putorius (Lat. putor, *a stench*). A genus of carnivorous mammalia, distinguished from the Martens, to which they are most nearly allied, by their shorter muzzle, the suppression of one premolar above and below, and the absence of an internal tubercle to the lower *carnassial* tooth. The polecat (*P. fœtidus*), of which the ferret is an albine variety, the weasel (*P. vulgaris*), and the stoat or ermine (*P. herminea*), form the English representatives of the genus.

Putrefaction (Lat. putrefacio, *I make rotten*). The spontaneous decomposition of animal and vegetable substances, attended by the evolution of fetid gases. The putrefaction (or putrefactive fermentation) of animal substances is usually attended by more fœtid and noxious exhalations than those arising from vegetable products. This appears principally referable to the more abundant presence of

nitrogen and of sulphur in the former; and hence the vegetables which abound in these principles (such as most, if not all, of the cruciferous plants) exhale similar effluvia: hence, also, such animal products as are destitute of nitrogen are either unsusceptible of what is commonly called putrefaction, or suffer it slowly and imperfectly. The formation of ammonia, or of ammoniacal compounds, is a characteristic of most cases of animal putrefaction; while other combinations of hydrogen are also formed, especially carburetted hydrogen, together with complicated and often deleterious vapours or gases, in which sulphuretted hydrogen is discerned. These putrefactive effluvia are for the most part easily decomposed, and resolved into new and comparatively innocuous compounds, by the agency of chlorine; hence the importance of that body as a powerful and rapidly acting disinfectant.

The rapidity of putrefaction, and the nature of its products, are to a great extent influenced by temperature, moisture, and access of air; they do not ensue below the freezing point, nor in dry substances, nor under the entire exclusion of oxygen; and hence various means suggest themselves of retarding or preventing putrefaction, as well as of modifying its results: a temperature between 60° and 80°, a due degree of humidity, and free access of air, are the circumstances under which it proceeds most rapidly. The most effective antiputrefactives or antiseptics are substances which either absorb or remove a portion of the water or moisture, and enter into new combinations with the organic matter; hence the great efficacy of certain salts, sugar, alcohol, and several other applications, among which, perhaps, the most remarkable are carbolic acid and some volatile oils, such especially as kreasote and other empyreumatic products obtained by the destructive distillation of wood, pyroligneous acid, and pyroligneous spirit: the latter is eminently useful in the preservation of dead bodies for the purposes of dissection, and, when properly and sufficiently injected into the vessels, and externally applied, indefinitely suspends the ordinary steps of the putrefactive process.

The astringent or tanning principle of vegetables is also a powerful preserver of most organic tissues; it enters into chemical combination with the albuminous and gelatinous membranes and fibres; and the resulting compound, of which leather furnishes a characteristic example, is comparatively little prone to change.

Among saline substances, the antiputrefactive powers of salt are commonly known. When a piece of flesh is salted, brine runs from it, in consequence of the energy with which the salt abstracts the water of the muscular fibre; the flesh becomes indurated, and its susceptibility to putrefactive changes greatly diminished; it becomes at the same time less easy of digestion as an article of food. Corrosive sublimate is a more powerful preservative than common salt; and it appears to act not by the mere abstraction of water, but by rendering impossible the developement of animalcules, to which, as Pasteur has lately demonstrated, all putrefactive processes are essentially due. Sulphate of copper and several other metallic salts are similarly efficacious; and the most putrescible substances, as for instance the brain, after having been steeped in such solutions and dried, will remain without further change for an indefinite period. The poisonous nature of these and many other metallic salts prevents their employment in the preservation of articles of food.

It is probable that the ancient Egyptians employed several of the above-mentioned antiputrefactive and preservative substances in the preparation of their mummies, which have remained for so many hundred years without signs of decay or decomposition. Yet in these and similar cases, when by the careful application of various solvents the preservative substances are removed, the flesh resumes its susceptibility of putrefaction.

The inhabitants of northern climates avail themselves of freezing to prevent the putrefaction of their food, and the supplies of game and other articles in the Russian markets are retained in a frozen state. Our fishmongers resort to the same expedient for the preservation of their unsold fish, which is daily removed to the ice-house after having been exhibited in their shops. Salmon is packed in ice for the purpose of transport and preservation. [PRESERVATION OF MEAT.]

It is curious to remark the wonderful influence of vitality in opposing those chemical changes which constitute putrefaction, and in retaining that arrangement of the organic elements which is requisite for the functions of life. When a part of the body dies, the phenomena of gangrene or mortification, i.e. of local putrefaction, ensue; and the putrefactive changes are the more energetic in consequence of the proximity of the dead part to the living.

All organic tissues may be indefinitely preserved by cautious desiccation; and it is in consequence of the comparative absence of water that the animal part of bone resists putrefaction. Dried bones may thus be stored up for ages; and when it is required to extract their nutritive parts, these are found but slightly impaired.

Putty (Fr. potée). In Architecture, a very fine cement used by plasterers, made of lime only. It differs from fine stuff in the manner of preparing it, and in its being used without hair. Also a composition used by glaziers for the purpose of fixing sheets of glass in the wood frames. It consists of whiting and linseed oil.

Pycnite (Gr. πυκνός, *dense*). Schorlous Topaz. A massive variety of Topaz, having a parallel columnar structure and oblique transverse divisions, along which it may be easily broken. It is translucent, and of a dull yellowish or reddish-white colour. It is a silicate of alumina, with one-seventh of the oxygen

replaced by fluorine. The chief localities where it is found, are at Altenberg, in Saxony; and Schlackenwald and Zinnwald, in Bohemia.

Pycnodontes (Gr. πυκνός, and ὀδούς, *tooth*). A family of fossil lepidoganoid fishes, in which the vomer, as in *Anarrhichas*, opposes its pavement of teeth to that of the two closely approximated premandibular or dentary elements of the under jaw. They were mostly deep-bodied fishes, symmetrically compressed from side to side. They were notochordal; a few of the earlier forms were heterocercal, but the majority of the family were homocercal. The family is found from the carboniferous to the earlier tertiary periods.

Pycnostyle (Gr. πυκνόστυλος). In Architecture, an arrangement of columns in which the intercolumniations are equal to one diameter and a half of the columns.

Pycnotrop. A kind of Serpentine.

Pygmy (Gr. πυγμαῖος, *dwarfish*; from πυγμή, *a cubit*). By ancient authors on natural history this name was applied to a fabulous race of dwarfish human beings; it is now restricted to a species of ape, the *Troglodytes niger* of Geoffroy St. Hilaire, or the chimpanzee. (Tyson's *Anatomy of a Pygmie*, with an Essay concerning the Pygmies of the Ancients, fol. 1699.) Homer (*Il.* bk. iii.) described a nation of pygmies dwelling somewhere near the shores of the Ocean stream, and maintaining perpetual wars with the cranes. Ctesias, the Greek historian, as quoted by Photius, represented a nation of them as inhabiting India, and attending its king on his military expeditions. Others believed them to inhabit the Indian islands; and Aristotle places them in Ethiopia, Pliny in Transgangetic India. These numerous fables appear to originate partly, as Strabo long ago observed, in the stunted growth of particular races, under the sufferings of a severe climate or great privations; thus the Esquimaux or Laplanders furnished the ancient Northmen with their legendary *Dwergar*, or nations of malicious dwarfs. Some of the low-caste races which inhabit the forests of interior Hindustan are feeble and puny enough to have given origin to the account of Ctesias; while the pygmies of the Malay Archipelago and the interior of Africa were probably apes.

Pyin. [Pus.]

Pylagoras (Gr. πυλαγόρας, so called from the assembly of the Amphictyons at Pylæ or Thermopylæ). The title of one of the two deputies from each confederate at the Amphictyonic Council. His functions comprised the diplomatic and deliberative duties of the mission: while the care of the sacred rites fell on his colleague, the Hieromnemon (ἱερομνήμων).

Pylorideans (a word coined from Gr. πυλωρός, *a gatekeeper*, and εἶδος, *likeness*). The name of a tribe of Lamellibranchiate Bivalves, comprehending those which have a shell open at both extremities.

Pylorus (Gr. πυλωρός). The aperture of the stomach into the duodenum; it guards, as it were, the entrance into the intestinal canal.

Pyocyanin. [Pus.]

Pyrallolite (Gr. πῦρ, *fire*; ἄλλος, *other*; and λίθος, *stone*). An altered form of Augite in which magnesia takes the place of lime. It occurs, of a greenish-white to a yellowish-grey colour, at Pargas in Finland, generally massive. The name has reference to the change of colour which takes place before the blowpipe.

Pyramid (Gr. πυραμίς). In Geometry, a solid contained by a plane polygonal base and other planes meeting in a point. This point is called the vertex of the pyramid; and the planes which meet in the vertex are called the sides or faces. These are necessarily all triangular.

The principal properties of pyramids are the following: 1. Every pyramid is equivalent to one-third of a prism having the same base and altitude. Hence, 2. All pyramids having equivalent bases and equal altitudes are equivalent. 3. The solid content of a pyramid is measured by the product of the area of the base into one-third of the altitude. 4. If a pyramid is cut by a plane parallel to its base, the frustum (or part comprehended between the base and the section) is equal to the sum of three pyramids having for their common altitude that of the frustum, and of which the bases are respectively the lower base of the frustum, the upper base of the frustum, and a mean proportional between them. (Legendre's *Geometry*, and Notes.)

Pyramids are denominated from the figures of their bases, being *triangular*, *quadrangular*, *pentagonal*, &c., according as the base is a triangle, a quadrangle, a pentagon, &c.

Pyramids of Egypt. Celebrated monuments of massive masonry, which, from a square base, rise by regular gradations till they terminate in a point, but so that the width of the base always exceeds the perpendicular height. The pyramids commence immediately south of Cairo, but on the opposite bank of the Nile, and extend in an uninterrupted range for many miles in a southerly direction, parallel with the banks of the river.

The three largest are situated in the vicinity of Ghizeh, not far from Cairo; and of these the loftiest is called the pyramid of Cheops, from the prince by whom it is supposed to have been erected. The sides of its base, which are in a line with the four cardinal points, measure at the foundation 763·4 feet; so that it occupies a space of more than 13 acres. Its perpendicular height is 480 feet, being, consequently, 43 feet higher than St. Peter's at Rome, and 136 feet higher than St. Paul's. Supposing this pyramid to be entirely solid, its contents would exceed three millions of cubic yards, and the mass of stone contained in it would be six times as great as that contained in the Plymouth breakwater! This huge fabric consists of successive tiers of vast blocks of calcareous stone, rising above each other in the form of steps. The thickness of the stones, which is identical with the height of the steps, decreases as the altitude of the pyramid increases, the greatest

height being 4·628 ft. and the least 1·686 ft. The mean breadth of the steps is about 1 ft. 9 in. The best authorities agree in estimating the number of steps or tiers of stone at 203. According to the information communicated to Herodotus by the priests, 100,000 men were employed for twenty years in the construction of this prodigious edifice; and ten years were employed in constructing a causeway by which to convey the stones to the place, and in their conveyance. (Lib. ii. § 124.)

The other pyramids, although of inferior dimensions, are mostly all of vast magnitude: they are not all of stone, some of them being of brick.

Many learned dissertations have been written to account for the original use and object of these imperishable structures. But the difficulty of the subject is such, that hitherto no satisfactory conclusion has been arrived at. Even in the remotest antiquity their origin was matter of doubt, and nothing certain was known with respect to them or their founders. (Plin. *Hist. Nat.* lib. xxxvi. § 12; Diodorus, i. 64.) Some have supposed that they were intimately connected with the religion of the ancient Egyptians; others have thought that they were at once a species of tombs and temples; while others again have maintained that they were designed to serve as gnomons, an opinion countenanced by the fact of their being placed in the direction of the four cardinal points. (Shaw's *Travels*, p. 170 &c. 4to. edit.; Greaves's 'Pyramidographia,' *Works*, vol. i.; Bunsen, *Egypt's Place in Universal History*; Piazzi Smyth, *Our Inheritance in the Great Pyramid*.)

The question of the date of the great Egyptian buildings has been examined by Sir G. C. Lewis in his treatise on the *Astronomy of the Ancients*, p. 440, &c., and his conclusion is that there is not sufficient historical ground for placing any of them at a date anterior to that of the building of the temple of Solomon, 1012 B.C. (*Edin. Rev.* Jan. 1857, p. 125; July 1862, p. 100.) This assertion has been received by some with 'profound astonishment.' It is, however, obvious that Sir G. C. Lewis does not fix their date, all that he asserts being that we have no *historical* warrant for ascribing them to an earlier age. According to Herodotus, the pyramid kings reigned from about 913 to 813 B. C. 'Astronomers, who tell us that 3,970 years ago the star γ Draconis fulfilled the office of a pole star, accept that date for the pyramids (B. C. 2123 for the great pyramid), because they have openings on the north side 'leading to straight passages, which descend at an inclination varying from 26° to 27°, the direction of these passages being in all cases parallel to the meridian: now if we suppose a person to be stationed at the bottom of any one of these passages, and to look up it as he would through the tube of a telescope, his eye will be directed to a point in the meridian 26° or 27° above the plane of the horizon; and this is precisely the altitude at which the star γ Draconis must have passed the lower meridian at the place in question 3,970 years before the present time.' (Chambers, *Handbook of Astronomy*, p. 270.) It might have been thought that the astronomical argument would have been welcomed by Baron Bunsen; but it did not fit in with his scheme, and hence apparently he has thrown the pyramids still further back by more than a thousand years.

The etymology of the word *pyramid* is involved in as great obscurity as the object of the structures themselves. Almost all the derivations that have been assigned to the term proceeded on the supposition that it is of Greek origin, than which nothing can be more erroneous. De Sacy regards the ις in πυραμίς as a Greek termination; the first syllable πυ he holds to be the Greek version of the Egyptian article *pi* (and so written by the Greeks from their wish to derive the word from πῦρ, *fire*); and he refers the syllable ραμ to the root *ram*, which, in the Egyptian language, signified *separating* or *setting apart from common use*: consequently, the word *pyramid* will denote a *sacred place or edifice* set apart for some religious purpose. (De Sacy, *Observations sur l'Origine du Nom donné par les Grecs et les Arabes aux Pyramides d'Ægypte*; M'Culloch's *Geog. Dict.* art. 'Egypt.')

Pyramids of Mexico. Some of the Mexican pyramids have a larger base than even the pyramids of Egypt. The pyramid of Cholula has a truncated form, and faces with its four sides the cardinal points, being divided into the same number of terraces. It is possible that the interior of this pyramid may be a natural hill, but more probably it is an artificial composition of stone and earth, deeply encrusted in every part with alternate strata of brick and clay. The perpendicular height of this pyramid is 127 feet, the base being 1,423 feet, or twice as long as that of the pyramid of Cheops. On the summit stood the temple of Quetzalcoatl, the god of the air. The larger of the two great pyramids of Teotihuacan, dedicated, the one to Tonatiuh, the sun, the other to Meztli, the moon, is 682 feet in length at the base. Around these are many smaller pyramids, rarely exceeding 30 feet in height, and said to have been dedicated to the stars. They served also as sepulchres for the chiefs of the nation. (Prescott, *Conquest of Mexico*, book iii. ch. i. and book v. ch. iv.)

Pyramidal Numbers. In Arithmetic, the successive sums of polygonal numbers, the latter being obtained by the successive summation of numbers in arithmetical progression. Pyramidal numbers are FIGURATE NUMBERS of the third order.

Pyrantimonite. Red Antimony-ore. [KERMESITE.]

Pyrargillite (Gr. πῦρ, *fire*, and ἄργιλλος, *clay*). A hydrated silicate of alumina, protoxide of iron, magnesia, soda and potash, found in granite at Helsingfors in Finland. It occurs massive and in prismatic forms with an indistinct cleavage, and in colour is partly black

and shining or partly bluish and lustreless; also liver-brown or dull red. According to Bischof, it is an altered form of Iolite.

Pyrargyrite (Gr. πῦρ, and ἄργυρος, *silver*). Dark-red ruby Silver-ore. A sulphantimoniate of sulphide of silver ($Ag\,S + Sb\,S_3$), containing about 60 per cent. of silver. It crystallises in complex modifications of the hexagonal system, and is also found massive. Colour deep blood red when seen by transmitted, and dark grey or black with an adamantine lustre, by reflected light. It is one of the most important of silver ores, and occurs in quantity in the Harz, Saxony, Bohemia, Hungary, and Mexico, also in Washoe Nevada, and the western states of South America. The light-red ruby ore is similar in form, and differs in composition only in the substitution of arsenic for antimony in the second term. [PROUSTITE.]

Pyrenees. This mountain-chain, rising like a wall separating Spain from France, is chiefly interesting in physical geography as connected with the table-land of Spain which extends between the Pyrenees and the Sierra Nevada, interrupted at intervals by several ranges of hills rising only to a moderate elevation. The Pyrenean chain is quite separated from the Alps, and has little resemblance to it either in its style of mountain scenery or in the forms of the valleys. The average height is considerable, the chain remarkably uniform, the general effect being that of a serrated ridge. The breadth of the range is comparatively small, nowhere exceeding sixty miles, and generally much less. The length is a little less than 600 miles from the gulf of Lyons to the Atlantic. The culminating point of the chain is rather more than 11,000 feet above the sea, and the sides are much steeper towards France than Spain. There are few passes, none of them being either good or practicable at all seasons, except two, one near Perpignan on the east, and one near Bayonne on the west.

Pyreneite. A black or greyish-black variety of Iron-lime Garnet, occurring in small but very perfect rhombic dodecahedrons, in the limestone of the Pic d'Ereslids, in the Pyrenees.

Pyrethrum (Gr. πύρεθρον, *feverfew*). One of the genera of *Compositæ* which have a medicinal reputation. The popular species is *P. Parthenium*, otherwise called Feverfew, from its being a domestic remedy in slight fevers. It possesses bitter tonic properties. Some forms of the plant in which the flower-heads consist wholly of ligulate florets, and others in which the quilled yellow disc florets of the wild plant are exchanged for large white quilled florets, both being of an ornamental character, are met with in flower gardens, notwithstanding their strong and not very agreeable odour.

Pyretology (Gr. πυρετός, *fever*, and λόγος). The doctrine of fevers.

Pyrexiæ (Gr. πύρεξις, *feverishness*). Febrile diseases. The first class in Cullen's nosology.

Pyrgom (Gr. πύργωμα, *a fortress*). A dingy green variety of Sahlite, found in the Fassa valley, in the Tyrol.

Pyridine. An oily organic base found amongst the products of the distillation of bone.

Pyrites (Gr. πυρίτης, sc. λίθος). This term was originally applied to the harder varieties of bisulphide of iron which strike fire with steel. The German equivalent *kies* probably expresses the same idea as *kiesel*, flint, for in the earliest forms of fire-arms the charge was ignited by a piece of pyrites striking against the steel covering the pan, the use of flints for the same purpose being a later improvement. At the present time, when used alone, pyrites is usually understood as expressing Iron Pyrites.

The various terms compounded of Pyrites, expressing sulphides and arsenides of different compositions, are translations of the corresponding compounds of *kies*. Such are Copper Pyrites, Arsenical Pyrites, Nickel Pyrites, Cobalt Pyrites, and Magnetic Pyrites. Taken as the name of a group in this way, the term Pyrites forms one of the three divisions of minerals, used by the old German miners, namely, *kies* or Pyrites (hard ores?), *glance* or glassy ores, and *blende* or brilliant ores. According to Koch, *marcasites*, another old term for Pyrites, is of Arabic origin, and also signifies fire-stone. The common term for Pyrites used in Cornwall is *mundic*.

Pyro-Acids. The prefix *pyro* is usually applied to the products which are obtained by subjecting certain organic acids to heat. The acids are thus altered in composition, and give rise to distinct classes of salts. Thus we have the pyrogallic, pyrocitric, pyrotartaric acids, &c.

Pyroacetic Spirit. A liquid formed during the destructive distillation of acetate of lead. [ACETONE.]

Pyrochlore (Gr. πῦρ, *fire*, and χλωρός, *pale green*). A compound of columbic and titanic acid with lanthanum, lime, potash, soda, zirconia, yttria, &c.; found in Norway, and near Miask in Siberia. The name refers to the change in colour, before the blowpipe, of the glass which the mineral forms with microcosmic salt.

Pyrodmalite (Gr. πῦρ, *fire*; ὀδμή, *odour*; and λίθος, *stone*). A name given to Pyrosmalite, from the odour which it gives off when heated.

Pyrolaceæ (Pyrola, one of the genera). A small natural order of the Erical alliance of hypogynous Exogens, distinguished by its semi-monopetalous flowers, its free perfect stamens, its loose-skinned seeds, and its baseless embryo. *Chimaphila umbellata*, a North American species of the order, is powerfully diuretic. Some *Pyrolas* are found wild in England.

Pyroligneous Acid (Gr. πῦρ, and Lat. lignum, *wood*). This term is generally applied to the *acid liquor* which passes over along with other products when wood is subjected to destructive distillation. This acid liquor is an impure vinegar, from which acetic acid is obtained as follows: The pyroligneous acid, freed from tar, is saturated with chalk or powdered slaked lime, filtered, and evaporated, by which an impure acetate of lime is obtained; this

is gently heated, so as to destroy part of its empyreumatic matter without decomposing the acetic acid; it is then mixed with sulphate of soda, which yields, by double decomposition, sulphate of lime and acetate of soda; the acetate of soda is filtered off the sulphate of lime, evaporated, heated cautiously in a reverberatory furnace, and redissolved and crystallised. In this way a pure crystallised acetate of soda is by proper management obtained, which is mixed in a retort or still with an equivalent proportion of sulphuric acid, a gentle heat being applied. The strong acetic acid then distils over, and sulphate of soda remains behind. This acetic acid is in a high state of concentration; it is lowered by the addition of water, and if intended for the table or for domestic use, as a substitute for other forms of vinegar, it is usually coloured with a little burnt sugar. The charcoal which is the residue of this distillation of wood is of an excellent quality. The charcoal employed in the manufacture of gunpowder is thus prepared. This manufacture of vinegar is now carried on upon a very large scale, and the greater part of the vinegar used for domestic purposes and in the arts, in many of which it is largely consumed, is derived from this source. The hard woods, such as beech, oak, birch, and ash, are most productive of acetic acid, some of them yielding as much as four per cent. [VINEGAR.]

Pyroligneous Spirit. [PYROXYLIC SPIRIT.]

Pyrolusite (Gr. πῦρ, *fire*, and λύσις, *a loosening*). A mineralogical term applied to the common black ore of manganese, in consequence of the ease with which it is resolved by heat into oxygen and a suboxide.

It is a binoxide of manganese, composed of 63·64 per cent. of manganese and 36·36 oxygen. It sometimes occurs crystallised, but generally in botryoidal and reniform masses, with a radiating structure, or in granular masses. The colour is often bluish, but more frequently steel-grey, inclining to iron-black, with a metallic lustre. It is so soft as to soil the fingers when handled; a test which serves to distinguish this mineral from Psilomelane, with which it is frequently associated. It is found in Cornwall and Warwickshire, in Saxony, Bohemia, France, Brazil, &c.

Pyrolusite is the most valuable of the ores of manganese, from the large amount of oxygen which is contained in it, and renders it of great value in the preparation of chloride of lime, and in bleaching. It is also employed in the manufacture of glass for discharging the brown and green tints, and other colouring matters; in enamel and glass painting, and in colouring pottery. (Bristow's *Mineralogy*.)

Pyromancy (Gr. πυρομαντεία). Among the classical ancients, a species of divination by means of the fire of the sacrifice; in which, if the flames immediately took hold of and consumed the victims, or if they were bright and pure, or if the sparks rose upward in a pyramidal form, success was said to be indicated. If the contrary took place, misfortunes were said to be presaged. (Soph. *Antig.* 1005, &c.)

Pyromelite (Gr. πῦρ, and μήλινος, *quince-yellow*, from its becoming of that colour when first heated before the blowpipe). A hydrated sulphate of nickel, occurring in interlacing capillary crystals, but chiefly as a greenish efflorescence, at Wallace Mine, Lake Huron.

Pyrometer (Gr. πῦρ, *fire*, and μέτρον, *measure*). An instrument for measuring higher temperatures than can be determined by an ordinary thermometer. Various contrivances have been employed for this purpose. Muschenbroek, who gave the name *pyrometer* to this instrument in 1730, adopted the following method: A prismatic rod, about six inches long, of the metal under trial, is attached at one extremity to an immovable obstacle, and heated by lamps, the other end being necessarily pushed forward; this being fastened to a rack playing into a pinion, communicates a revolving motion to an axle to which a train of wheel-work is attached; and thus the minutest expansion of the heated bar is rendered sensible, and measured by an index on a dial. This method is liable to several objections, and the absolute temperature communicated to the bar by the lamps is entirely unknown. Desaguiliers, and afterwards Ellicott, made several improvements in the construction of the instrument, tending to give it a more equable motion and to increase its delicacy. Graham substituted a micrometer screw for the wheels and levers that had formerly been employed; and on this principle Smeaton contrived a far more accurate instrument with which the $\frac{1}{23\,000}$th of an inch of expansion was determinable. With this pyrometer Smeaton ascertained the expansion of various solids between the freezing and boiling points of water, and his results agree remarkably well with recent observations.

An ingenious mode of indicating the expansion of a metal bar by heat was invented by Ferguson, originally for lecture illustration, for which purpose it is well suited. By means of two levers of the second order the powerful motion of the expanding bar was converted into a considerable deviation of a long but light index, moving over a graduated arc. Though thus simple in its construction, this instrument is said to be delicate enough to show variations of its index merely from the heating of its metal bars by slight friction. Subsequently, Ferguson rendered his instrument so sensitive that it readily showed the expansion of a bar to the $\frac{1}{75000}$ of an inch. A more accurate method of measuring the dilatation of a bar by heat was devised by Ramsden, for the purpose of determining with the greatest precision the expansibility of the rods employed by General Roy in his trigonometrical survey. The expansion of the tested bar, which was caused to pass through changes of temperature, was compared with a standard bar kept at a constant temperature. This was done by direct observation through two microscopes provided with cross wires; the amount of this expansion

was ascertained by the movement which it was necessary to give to a micrometer screw in order to bring the expanded bar back to its initial position.

The instruments thus far described, though called pyrometers, have little claim to this term, for practically they are incapable of measuring very elevated temperatures, and even if they could do so their indications are unconnected with the ordinary thermometric scale. Wedgwood, by means of the pyrometer which bears his name, was the first to accomplish this object with any degree of success. He had found by repeated trials that fine porcelain clay contracted uniformly with the degree of heat applied to it, and on cooling remained thus contracted. Accordingly, by measuring the dimensions of a cylindrical piece of this substance, which was done with great accuracy by observing the depth to which it sank between two scales of metal inclined to each other under a small angle, and subjecting it to the heat of a furnace, then applying the scale again to it when cold, an indication of the degree of heat to which it has been subjected was given by the amount of its contraction. Wedgwood divided his scale into 240°; and, in order to compare it with that of Fahrenheit's thermometer, made use of a piece of silver fitted to the same mould as the pyrometric pieces of clay. Having determined the expansion of the silver between 50° and 212° of Fahrenheit's scale, he subjected the silver and clay to the same heat; and, by a comparison of the expansion of the one with the contraction of the other, he estimated that each degree of his scale was equal to 130° of Fahrenheit's. He also estimated that the zero of his scale corresponded with 1077·5° of Fahrenheit's; and from these data comparative tables of the two scales were formed. Clay, however, is a heterogeneous mixture, varying in its composition, and even different portions of the same clay might possess different contractile powers; the cylinders could not therefore be always alike, and thus their indications were not always the same. This uncertainty, and the erroneous conclusions to which Wedgwood was led by his pyrometer, caused it to be abandoned soon after its invention in 1782, and it has long since become obsolete. But Wedgwood's greatest error lay in the conversion of the scale of his pyrometer into degrees of Fahrenheit's thermometer. It was subsequently shown by Guyton de Morveau, and since confirmed, that Wedgwood assigned far too high a temperature for the degrees of his scale. The cause of this error was in the comparison of the contraction of clay with the expansion of silver, the connecting link between the Wedgwood and Fahrenheit degrees. Guyton, by means of his pyrometer, next to be described, estimated that each degree of Wedgwood, instead of being 130° Fahr., ought not to have been more than 62·5° Fahr., while the commencement of his scale should have been 517° Fahr. instead of 1077°.

Guyton de Morveau, in 1804, invented a platinum pyrometer, which, though a great improvement on Wedgwood's, yet, as subsequently pointed out by Daniell, was rendered liable to error by the softening and consequent flexibility of the platinum at high temperatures. This instrument is very similar to one constructed by Brongniart for determining the temperature of the porcelain furnaces at Sèvres; Brongniart using, however, a bar of silver instead of platinum. Guyton de Morveau's pyrometer consisted of a solid plate of highly baked porcelain, in which a groove was cut containing a flat bar of platinum, an inch and three-quarters in length, two-tenths of an inch broad, and one-tenth of an inch thick. One end of the bar abuts against the bottom of the groove, the other presses against the short arm of a bent lever, of which the long arm, moving on a pivot, becomes the index of the instrument and marks the degrees on a scale fixed to the porcelain. Guyton connected these degrees with those of the ordinary mercurial thermometer, and accordingly was able to give in Fahrenheit degrees the fusing points of various metals. As we have already noticed, he corrected Wedgwood's scale, which, thus altered, furnished a table of high temperatures, far nearer the truth than it was originally.

Daniell, unaware of Guyton's pyrometer, invented one on somewhat the same principle, but certainly more trustworthy in its indications. In this pyrometer a mixture of black lead and clay was substituted for the porcelain in the former; the part by which the heat was to be determined being in Daniell's original instrument a rod of platinum, ten inches in length and a seventh of an inch in diameter, placed within a tube of black-lead ware, and having one end fixed at the bottom of the tube; to the other end was attached a fine wire of platinum, which, after passing two or three times round the axis of a wheel, was fastened to a spring by which it was always preserved at the same degree of tension. The teeth of the wheel played into a pinion, the axis of which carried an index, whose revolution showed, on a greatly magnified scale, the expansion and contraction of the platinum rod.

In 1830 Daniell improved his pyrometer by dividing it into two parts, one of which he termed the *register*, the other the *scale*. The *register* was the part exposed to the temperature to be determined, and consisted of a rod of metal, generally wrought iron, dropped within a tube of black lead. The heat expanded the metal more than the plumbago, and the *scale*, by a rule and vernier, measured this relative expansibility of the platinum. Reducing his scale by experiment to that of Fahrenheit, Daniell determined the fusing point of several metals; the results of some of his experiments are given in the article TEMPERATURE.

In a paper read before the Paris Academy of Sciences in 1836, Pouillet proposed three

methods of measuring high temperatures. The first method, which was originally used by Prinsep in 1827, consisted in employing the dilatation of a gas by heat, instead of the expansion of a solid. Pouillet's air pyrometer is a cylindrical vessel of platinum, containing air; connected with the vessel is an exit tube, also of platinum, which leads into a manometer, by the depression of the mercury in which the amount of the expansion of the air in the vessel, when exposed to a high temperature, can be determined. Knowing how much air enlarges in bulk for every degree of temperature, in other words, knowing the coefficient of expansion of air, and having found how much air has been expelled by the source of heat, we are enabled by a simple calculation to find the temperature to which the pyrometer has been exposed. The second method suggested and used by Pouillet was the production of a thermo-electric current by the union of platinum and iron, the junction being exposed to the source of heat. Equal increments of heat were found up to a high limit to produce equal additions to the strength of the current. By means of a tangent galvanometer the strength of the thermo-electric current could be accurately measured, and in this way Pouillet succeeded in finding the fusing points of a number of metals; the results obtained by his two pyrometers agreeing fairly. With the same instruments as those here described, Pouillet subsequently determined very low temperatures, with great accordance in the different means of measurement. The third means of measuring high degrees of heat, suggested by Pouillet, differs in its principle from other pyrometers. The difference between the specific heat of platinum and water is employed to determine the temperature to which the former has been raised. The specific heat of water being 1, that of platinum at high temperatures is ·0373; in order, therefore, to raise an ounce of water one degree, about 28 times more heat is needed than to raise an equal weight of platinum to the same temperature. If 200 ounces of platinum heated in a furnace raise 1,000 ounces of water 12½°, it can readily be found that the temperature of the platinum before immersion was 1756°. In this way Pouillet has determined some high temperatures, and the principle has been suggested for use in certain arts, employing a copper ball instead of platinum; it requires, however, skill and repetition to avoid several sources of error.

Owing to the investigations of Regnault, our knowledge of the rate of expansion of gases has of late become far more accurate. This circumstance, and the improvements in the apparatus made by Regnault, greatly increased the value of measurements made by the air pyrometer. But, quite recently, doubts of the accuracy of the indications of this instrument have arisen from an unexpected cause. In the course of his researches, M. H. St. Cl. Deville discovered that platinum and iron, to a certain extent, become porous when at a white heat. A platinum vessel, therefore, containing air, or still more hydrogen, would at a high temperature permit the passage of a portion of the enclosed gas through its substance; hence, as experimentally established by Deville and Troost, this becomes a serious source of error, to which air pyrometers made of these metals have all been exposed. Deville and Troost, in a series of measurements of high temperatures, have advantageously replaced air by the vapour of iodine, or of that of some of the metals; using, moreover, instead of platinum a vessel of porcelain.

M. Ed. Becquerel has recently made some researches on the measurement of high temperatures, which are published in the *Comptes Rendus* of the Paris Academy for December 1862 and November 1863. M. Becquerel's pyrometer is a thermo-electric couple formed by the union of a wire of platinum with another of palladium; the current generated regularly increasing with the temperature up to the fusion of palladium at about 1500° C. = 2730° Fahr. Observations with this pyrometer caused M. Becquerel to suggest an *optical* pyrometer; a means of determining any temperature, however elevated, by measuring the intensity of the light emitted from the glowing source. The point of fusion of platinum he thus estimates at 1600° C. or 2910° Fahr., and the temperature of the positive carbon in the voltaic arc at 2070° C. or 3760° Fahr. M. Becquerel has, by means of the thermo-electric and air pyrometer, determined the boiling points of some of the metals. The correctness of the numbers which he obtained has, however, been disputed.

Under the article TEMPERATURE the measurements of various high temperatures obtained by different experiments are given at length.

Pyromorphite (Gr. πῦρ, and μορφή, *form*). Native chloro-phosphate of lead, found at Huel Penrose, and other Cornish mines, and in Devonshire, Derbyshire, Cumberland, and Leadhills in Lanarkshire. When heated before the blowpipe, it fuses into a globule, and the name has reference to the polyhedral crystalline form which such a globule assumes in cooling.

Pyrope (Gr. πῦρ, and ὄψις, *appearance*). Precious Garnet. A dark red variety of Garnet seldom found crystallised, but generally in rounded or angular grains. This stone, which is of a full crimson-red colour, approaching to that of a ripe mulberry, is much used in jewellery. Sometimes it is called *fire garnet*, from the resemblance of its hue, when held between the eye and the light, to that of a burning coal. It is procured chiefly from Bohemia, Saxony, and Ceylon.

Pyrophane (Gr. πῦρ, and φαίνομαι, *to appear*). A variety of semi-opal which becomes transparent on being heated.

Pyrophorus (Gr. πῦρ, and φέρω, *I bear*). A substance which spontaneously takes fire when exposed to air. *Homberg's* pyrophorus is made by mixing equal weights of alum and

brown sugar, and stirring the mixture over the fire in an iron ladle till quite dry; it is then put into an earthen or coated glass bottle, and heated red-hot so long as a flame appears at the mouth; it is then removed, carefully stopped, and suffered to cool. The black powder which it contains becomes glowing hot when exposed for a few minutes to the air. The experiment succeeds best in a damp state of the atmosphere, and the ignition is frequently accelerated by breathing upon the powder. A mixture of 3 parts of lampblack, 4 of dried alum, and 8 of carbonate of potassa, may be substituted for the above, and calcined in the same way: 27 parts of sulphate of potassa and 15 of calcined lampblack, heated to redness in a crucible, and then carefully preserved out of contact of air, also yield a good pyrophorus.

It appears from Gay Lussac's experiments that the essential ingredient in these pyrophori is sulphuret of potassium; the charcoal and alumina only act by being interposed between its particles; but, when the mass once kindles, the charcoal takes fire and prolongs the combustion. An excellent pyrophorus is afforded by heating tartrate of lead red-hot in a glass tube, in which it may afterwards be hermetically sealed. When the tube is broken, and the black powder within it shaken out through the air, it burns with the emission of a dense smoke of oxide of lead. The spontaneous inflammability of this pyrophorus is probably due to minutely divided lead.

Pyrophyllite (from Gr. πῦρ, and φύλλον, *a leaf*; as exfoliating before the blowpipe). A hydrated silicate of alumina of a white or a pale green colour. It occurs foliated like talc (which it was formerly supposed to be), and often in fibrous radiated masses, and small elongated prisms, in the Ural, at Westana in Sweden, and at Cottonstone Mountain, North Carolina, also in Georgia and California.

Pyrophysalite (Gr. πῦρ, and φυσαλίς, *a bubble*). A coarse and nearly opaque variety of Topaz, found occasionally in large yellowish-white crystals at Finbo and Broddbo in Sweden.

Pyropissite (Gr. πῦρ, and πίσσα, *pitch*). A mineral resin, resembling earthy brown coal in appearance, met with at Weissenfels in Prussia.

Pyrorthite (Gr. πῦρ, and ὀρθός, *straight*). Probably a decomposed Orthite, containing bituminous matter, found in granite at Kararfoet near Fahlun in Sweden. When gently heated on one side it takes fire and burns; hence the name.

Pyrosiderite. [PYRRHOSIDERITE.]

Pyrrhosiderite (Gr. πυῤῥός, *brown*, and σίδηρος, *iron*). A brown hydrous peroxide of iron (Göthite) from Eiserfeld in Nassau.

Pyrosis (Gr. πύρωσις, from πυρόω, *I set on fire*). A disease of the stomach, attended by a burning sensation, and the throwing up of a quantity of saline fluid; it is sometimes called *water brash* and *black water*.

Pyrosklerite (Gr. πῦρ, and σκληρός, *hard*; from its refractory behaviour before the blowpipe). A green or reddish hydrated silicate of magnesia and alumina, found in foliated and fibrous masses at Elba, and at Åker in Sudermannland, Sweden.

Pyrosmalite (Gr. πῦρ; ὀσμή, *odour*; and λίθος, *stone*). A native silicate of iron, with chloride of iron, which, when heated, exhales the odour of chlorine. It occurs massive, and in six-sided prisms, at Nya Kopparberg in Sweden, and at one of the iron mines of Nordmark near Phillipstad.

Pyrosoma (Gr. πῦρ, and σῶμα, *a body*). The generic name of certain pelagic floating compound Ascidians, remarkable for the brilliant phosphoric luminosity which they emit.

Pyrotechny (Gr. πῦρ, and τέχνη, *art*). This term denotes, in its widest sense, the art or science which teaches the management and application of fire to certain operations; but it is most usually restricted to those articles and instruments manufactured for amusement, or for exhibition on grand public occasions. The origin of artificial fireworks is lost in obscurity. They were in general use in China long before their introduction to Europe, which is comparatively of recent date. The finest inventions of this kind are due to the celebrated Ruggieri, father and son, who executed in Rome and Paris, and the principal capitals of Europe, the most brilliant fireworks ever seen.

Fireworks are divided into three classes:—
1. Those to be set off upon the ground;
2. Those which are shot up into the air; and
3. Those which act upon or under water.

The three prime materials of their composition are, nitre, sulphur, and charcoal, along with filings of iron, steel, copper, zinc, and resin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed, or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a very coarse file and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a more brilliant fire with wavy radiations. Copper filings give a greenish tint to flame, those of zinc a fine blue colour; the sulphuret of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire, as well as colophony and common salt; but the last must be very dry. Lampblack produces a very red colour with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand or glistening mica communicates to fireworks golden radiations. Verdigris imparts a pale green; sulphate of copper and sal-ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoin and storax are used also on account of their agreeable odour. Lycopodium burns with a rose colour and a magnificent flame; it is principally employed in theatres to represent lightning, or to charge the torch of a fury. (See, for full information as to the

various processes adopted in the construction of fireworks, Ure's *Dictionary of Arts, &c.* art. 'Fireworks.')

Chinese or Japanese Fire.—This composition, which may be either rammed into cases ¼ of an inch in diameter, or folded up in quantities of about 1 or 1½ grain in slips of tissue paper, consists of—

Nitrate of potash	3¼ parts
Sulphur	1½ part
Lampblack	1 „

These ingredients should be well incorporated, after being first passed through a fine sieve. If put into a case, the mixture burns slowly, throwing out splendid coruscating sparks which, from some fancied resemblance to the rowel of a spur, caused this mixture to be formerly called *spur fire.* These magnificent sparks are perhaps seen to best advantage when the composition is enclosed in tissue paper, as above described. These charged papers have recently become known under the name of *Japanese matches.*

PYROTECHNY. In Military Art, the science of the manufacture of artificial fireworks, and all combustible materials, including the compositions for rockets, fuses, carcasses, &c. &c., together with their use and application.

Pyroxanthin (Gr. πῦρ, and ξανθός, *yellow*). A crystalline yellow derivative of the action of alkalies upon wood-tar.

Pyroxene (Gr. πῦρ, and ξένος, *a guest*). A mineral isomorphous with Hornblende, but differing from it in containing a smaller quantity of silica, in being less fusible, and in having a higher specific gravity. The name indicates that it is a guest in the domain of fire, or that it is supposed to have pre-existed in the lava in which it is contained, and is not therefore a result of crystallisation consequent on the cooling of the mass. [AUGITE.]

Pyroxylic Spirit, Wood Spirit, or **Methylic Alcohol.** When wood is subjected to destructive distillation there is formed, besides tar, acetic acid, and other products, a variable portion, but not amounting on an average to more than about 1 per cent., of an inflammable and volatile liquid. This may be separated, to a certain extent, from the water and acetic acid, by distillation and separation of the first products. These, redistilled and rectified over quicklime, afford the *pyroxylic spirit* or *methylic alcohol* of commerce. If it contain ammonia, it should be neutralised, by sulphuric acid, previous to its last rectification. To obtain perfectly pure pyroxylic spirit, an excess of chloride of calcium is added, and the mixture is distilled in a water-bath so long as any volatile matter goes over. A compound of wood-spirit with chloride of calcium remains in the retort, to which a quantity of water, equal to that of the original spirit, is added, and the distillation then continued. The product which is now obtained, and which is pure pyroxylic spirit diluted by a little water, may be dehydrated by a final distillation off quicklime. Pyroxylic spirit is the *alcohol* of the *methylic* series. It is a limpid liquid, of a penetrating odour, partaking of that of alcohol and acetic ether, with an aromatic taint which has been compared to peppermint. Its taste is hot and pungent. Its specific gravity at 60° is 0·7398. It is very inflammable, and burns with a pale flame resembling that of alcohol. It boils at about 150°; the density of its vapour is 1·125. When pure it is not altered by exposure to air or light, but when subjected to the slow action of platinum-black, it yields, together with other products, *formic* acid; not acetic acid, as is the case with alcohol. If pure, it is neutral, and mixes in all proportions with water, alcohol, and ether, without becoming turbid. Its solvent powers, in regard to *salts,* closely resemble those of alcohol; it dissolves the resins, and may be used as a substitute for alcohol in almost all varnishes, but its odour is objectionable. It is a powerful antiseptic, and preservative of animal matter.

Pyroxylic spirit has the formula of $C_2H_4O_2$, or as hydrated oxide of methyl of C_2H_3O,HO or MeO,HO.

Methylated Spirit.—A mixture of 90 per cent. of alcohol and 10 per cent. of methylic alcohol is much used in the arts and manufactures, as well as in medicine and chemistry, as a substitute for rectified spirit.

Pyroxyline. The manufacture of this substance for military purposes, and its composition when so prepared, are noticed under the article GUN COTTON. In the chemical laboratory the following process may be resorted to for its production. Dry and clean carded cotton-wool is steeped in a mixture of three volumes of nitric acid (sp. gr. 1·5) with five of sulphuric acid; the mixture is allowed to cool, and small portions of cotton should be used at a time, so as to avoid elevation of temperature. In ten or twenty minutes the cotton may be withdrawn (the excess of acid pressed out), and thoroughly washed in water containing a little ammonia; it is then cautiously dried, at a temperature not exceeding 200° Fahr. 100 parts of cotton thus treated yield about 177 of dry gun cotton. Clean paper, the purer varieties of sawdust, and other forms of ligneous matter, produce similar compounds. Pyroxylic paper is remarkable for the intensity of its electricity when slightly rubbed. Well-prepared pyroxyline resembles the original cotton in appearance, but is more harsh and brittle, and highly electric. Its extreme combustibility is very remarkable. Inflamed in the open air it flashes off without smoke or residue; it takes fire at a much lower temperature than that required for the ignition of gunpowder, and its combustion is more rapid. The temperature at which gun cotton is inflamed is about 277° Fahr., but the different varieties of it no doubt require different temperatures for their ignition. When substituted for gunpowder in firearms, the extreme suddenness of its explosion would be apt to burst the barrel, unless precautions were

taken to prevent the simultaneous ignition of the whole charge. When this is done, however, it has now been shown that pyroxyline can be safely and with great advantages substituted for gunpowder in fowling-pieces. It is not deteriorated in damp air, or even (when subsequently dried) by immersion in water; and, weight for weight, its explosive force is between three and four times greater than that of gunpowder. The extreme rapidity of its combustion is well shown by placing a flock of it upon a small heap of gunpowder, where it may be exploded by a hot wire without kindling the powder. Aqueous vapour, carbonic oxide, carbonic acid, and nitrogen, are the only products of its combustion in a closed space, but in the open air it forms also traces of nitrous acid.

Under the name of *collodion*, a solution of pyroxyline in a mixture of alcohol and ether is largely used by photographers. For such purposes Mr. Nicol recommends the following formula. Ten ounces, by measure, of sulphuric acid (1·840), and five ounces, by measure, of nitric acid (1·370), are to be well mixed, and two fluid drachms of water added. When the mixture has cooled to about 130°, place in it, tuft by tuft, well pulled out, five drachms of clean cotton. Each tuft should be penetrated by the acid as it is immersed, and kept in for ten minutes, then removed, well washed, and dried. This compound is soluble in a mixture of alcohol and ether, and the solution leaves, on evaporation, a smooth transparent film.

The composition of pyroxyline varies with the mode of preparation. It is generally regarded as a substitution compound in which peroxide of nitrogen (NO_4) replaces one or more atoms of the hydrogen of the cotton-fibre. According to Hadow, the most explosive variety (insoluble in a mixture of alcohol and ether) may be represented by the formula $C_{36}\,O_{30}\,H_{21},+\,9\,NO_4$, and the less explosive variety used in making collodion, and therefore soluble in a mixture of alcohol and ether, as $C_{36}\,O_{30}\,H_{22},+\,8\,NO_4$, so that in the former nine, and in the latter eight, atoms of the hydrogen of the cotton are replaced by peroxide of nitrogen, assuming cotton fibre as $C_{36}\,H_{30}\,O_{30}$.

Pyrrha. In Mythology. [DEUCALION.]

Pyrrhic Dance. A species of warlike dance called by the Romans *Pyrrhica Saltatio*, said to have been invented by Pyrrhus to grace the funeral of his father Achilles. This dance consisted chiefly in such an adroit and nimble turning of the body as represented an attempt to avoid the strokes of an enemy in battle, and the motions necessary to perform it were looked upon as a kind of training for the field of battle. This dance is supposed to be described by Homer as engraved on the shield of Achilles. Lord Byron describes the Suliotes as still performing this dance (*Childe Harold*).

Pyrrhite (Gr. πυῤῥός, *yellow*). A mineral occurring in minute octahedrons of an orange-yellow colour, at Alabaschka in Siberia, and the Azores. It is probably columbate of Zirconia coloured by the oxides of iron, uranium, and manganese.

Pyrrhonists. The followers of Pyrrho, a philosopher of Elis, and disciple of Anaxarchus, who flourished about 300 B.C. Their tenets, which have come to us only through the reports of unfriendly writers, are said to have been so absurdly sceptical, that they would not put even as much confidence in the senses as was necessary for the preservation of their existence; but this seems partly refuted by the age at which Pyrrho himself died, which was ninety years. There is a summary of the doctrines of Pyrrhonism in the 2nd vol. of the historical part of the *Encyc. Metropolitana*; see also Hallam, *Literary History*, part ii. ch. iii. § 17, and ch. iv. § 8, and part iii. ch. iii. § 87. [SCEPTICISM.]

Pyrrhotine (Gr. πυῤῥότης, *redness*). Magnetic Iron Pyrites. A sulphide of iron composed of 60·5 per cent. of iron and 39·5 sulphur. It generally occurs massive and amorphous, but sometimes crystallised, in irregular and variously modified six-sided prisms. The colour, which is bronze-yellow, reddish, or brownish, is liable to become speedily tarnished on exposure to the air. It is found in Cornwall, Devonshire, and Cumberland, in North Wales, and Scotland. In Ireland it is met with of a bronze colour near Leahtown, Donegal. [MAGNETIC PYRITES.]

Pyrrol. An empyreumatic oil formed during the destructive distillation of bone.

Pyrus (Lat. pirus, *a pear-tree*). The genus of *Pomaceæ* or *Rosaceæ*, to which belong the Apple and Pear. In these fruits the ovaries become united, and form with the calyx-tube a fleshy mass enclosing about five leathery or cartilaginous cells, within which are one or two pips. This consistence of the cells is the chief distinction between *Pyrus* and *Cratægus*, the cells of the latter being hard and bony. Besides the Apple, *P. Malus*, and Pear, *P. communis*, the genus includes the Service-tree, *P. Sorbus*, the White Beam-tree, *P. Aria*, and the Mountain Ash or Rowan, *P. Aucuparia*. From the fruit of the latter a jelly is made which is highly esteemed as an adjunct to venison. [APPLE; PEAR.]

Pyruvic Acid. An acid discovered by Berzelius amongst the products of the destructive distillation of racemic and of tartaric acid.

Pythagorean Theorem. In Geometry, the theorem which forms the forty-seventh proposition of Euclid's first book, and according to which the sum of the squares on the sides of a right-angled triangle is equal to the square on the hypothenuse.

Pythagoreans. The followers of Pythagoras, a native of Samos, said to have been the first Greek who assumed the title of a philosopher. The date of his birth and the extent of his scientific travels are matters of great uncertainty (Sir G. C. Lewis, *On the Credibility of Early Roman History*, vol. i.

p. 451; *Astronomy of the Ancients*, 123–269); but he is said finally to have fixed his abode at Crotona, one of the Dorian colonies in the south of Italy. He here attached to himself a large number of youths of noble descent, whom he formed into a secret fraternity for religious and political as well as philosophical purposes; and by their assistance produced many beneficial changes in the institutions of Croton and the other Græco-Italian cities. Of the strictly philosophical tenets of the Pythagoreans very imperfect records are preserved. Many of the doctrines ordinarily imputed to them are evidently the fabrication of the later Pythagoreans, a class of visionaries who lived during the decline of the Roman empire. One point is sufficiently evident, that the Pythagoreans were the greatest mathematicians of their time, and that they sought in the study of mathematical relations that solution of the principal philosophical problems for which their contemporaries, the Ionic and Eleatic philosophers, sought, the first in physical, the others in ontological hypotheses. The relations of space and quantity, as they are the most obvious, are also the most definite forms, in which the laws of the outward world can present themselves to this faculty. Hence, as the atomic philosophers have endeavoured to explain all things by a diversity in the figure of their ultimate parts, the Pythagoreans seem to have found, in the number and proportions of those parts, the true essence of the things themselves. Having proceeded thus far, they went a step farther. They perceived that the universe and its parts are obedient to certain laws, and that these laws can be expressed by numbers. By a mistake prevalent during every period of speculation, they mistook the necessary conditions of a thing's subsistence for the essence of that thing itself; and at once pronounced that numerical relations were not merely all that could be understood in outward phenomena, but were, in fact, all that was real in them. Units of number grew gradually into points in space, and these into material atoms. To every order of existence, even to many abstract conceptions, a distinct number was assigned. God is represented as the original unity; the human soul, the earth, the planets, the animal creation have each their own peculiar arithmetical essence; as have also the abstractions *justice*, *opportunity*, *opinion*, &c.

The outlines of a duallistic scheme are discernible in a singular table of opposites (*συστοιχία*), preserved to us by Aristotle, in which the two principles of the universe are successively represented under the form of limit and the unlimited, odd and even, one and many, right and left, male and female, still and moved, straight and curved, light and darkness, good and evil, square and oblong.

For the character and working of the Pythagorean brotherhoods, see Grote's *History of Greece*, part ii. ch. xxxvii. An account of the astronomical theories of Pythagoras and his followers is given by Sir G. C. Lewis, *Astronomy of the Ancients*, p. 13, &c. See also Thirlwall's *History of Greece*, vol. ii. c. xii.; Ritter's *History of Philosophy*, b. iv.; Boeckh's *Philolaus*, &c.

The doctrine of Metempsychosis, or the transmigration of souls through different orders of animal existence, is the main feature by which the Pythagorean philosophy is popularly known. It is, however, by no means certain that the genuine Pythagoreans held this doctrine in a literal sense. It may have been only a mythical way of communicating their belief in the individuality of the soul and its existence after death.

Pythia (Gr.). The name of the priestess of the Delphian oracle of Apollo. [Oracle.]

Pythian Games. One of the four great national festivals of Greece, celebrated every fifth year in honour of Apollo, near Delphi. Their institution is variously referred to Amphictyon, son of Deucalion, founder of the council of Amphictyons, and Diomedes, son of Tydeus; but the most common legend is that they were founded by Apollo himself, after he had overcome the dragon Python. The contests were the same as those at Olympia, and the victors were rewarded with apples and garlands of laurel. [Delphi.]

Python (Πύθων). In Greek Mythology, the name of the dragon slain by Apollo. [Phœbus; Perseus.] The name was interpreted by the word πύθω, *to rot*, because its dead body was left to rot at Delphi; but this explanation is of no more value than that which professes to account for the name Lycaon. [Rishis.] In Teutonic myths, Python reappears as Fafnir. [Mythology, Comparative; Œdipus; Persephonê; Sigurdr.]

Python. In Zoology, the name of a genus of large Ophidian reptiles, having anal hooks, and a double series of sub-caudal scutæ.

Pyx (Gr. πυξίς, *a box of box-wood*). The name given to the box in which the host is kept by the Roman Catholic priesthood.

Pyx, Trial of. [Coinage.]

Pyxidium (Gr. πυξίδιον, dim. of πυξίς). In Botany, a fruit which divides circularly into a lower and upper half, of which the latter acts as a kind of lid, as in the Pimpernel.

Pyxis Nautica. The Mariner's Compass. A constellation of the southern hemisphere formed by Lacaille.

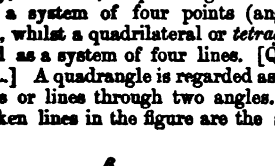
Q

Q. In all the languages in which it is used this letter is invariably followed by *u*, the combination being represented in English pronunciation by the letters *kw*, as in *quote*. Q is used as an abbreviation for *question*; Qy. for *query*; Q. E. D. for *quod erat demonstrandum*, which was to be demonstrated, &c.

Quader Sandstone. The cretaceous rocks of the north of Germany chiefly consist of sandstones, called *Quader sandstones*. There are two divisions—the *Upper Quader*, corresponding nearly in geological age to the main body of the chalk in England and Europe, and the *Lower Quader*, which represents our upper greensand and firestone. These German beds are not without calcareous matter, but it is chiefly present as a cementing medium. They are fossiliferous towards the base. Parts of them are much used as building material, and are well adapted for this purpose.

Quadragesima (Lat. *fortieth*). In the Calendar, a term applied to the time of Lent, because it consists of about forty days. *Quadragesima* Sunday is the first Sunday in Lent, and about the fortieth day before Easter.

Quadrangle (Lat. quadrangulus, *four-cornered*). A figure with four angles and four sides; in short, a quadrilateral. This is the ordinary acceptation of the term. In modern geometry, however, a quadrangle or *tetragon* denotes a system of four points (angles or corners), whilst a quadrilateral or *tetragram* is regarded as a system of four lines. [QUADRILATERAL.] A quadrangle is regarded as having six sides or lines through two angles. Thus the broken lines in the figure are the sides of



the quadrangle a, b, c, d, and α, β, γ, are the three *intersections of opposite sides*, which latter are sometimes called the *diagonal points* of the complete quadrangle. One of the most important properties of the quadrangle is that the rays joining any one of these three diagonal points with the other two are harmonic conjugates with respect to the sides which pass through the first point. Thus $\alpha\,(a\,b\,\beta\,\gamma)$, $\beta\,(a\,b\,\gamma\,\alpha)$, $\gamma\,(a\,d\,\alpha\,\beta)$ are harmonic pencils.

Quadrans (Lat.). A division of the Roman *as*, consisting of one-fourth of it, or three ounces when the *as* was of its full weight. [AS; FARTHING; PENNY; TRIUNCIUS.]

Quadrant. A mathematical instrument, formerly much used in astronomy and navigation. The instrument is variously contrived and fitted up, according to the purpose for which it is intended; but it consists essentially of a limb or arc of a circle equal to the fourth of the circumference, and divided into 90°, with subdivisions. The mural quadrant is of considerable size (six or eight feet radius, for example), the axis of which moves in a wall or solid piece of masonry. [MURAL CIRCLE.] Ptolemy, in the *Almagest*, describes a quadrant with which he determined the obliquity of the ecliptic. Tycho Brahe had a large mural quadrant for observing altitudes, and others which revolved on a vertical axis for measuring azimuths. Picart, in his measurement of the earth, used a quadrant for his terrestrial angles. In 1725 a mural quadrant, by Graham, was erected in the Royal Observatory at Greenwich, which, in 1750, was replaced by Bird's quadrant, with which Bradley made his celebrated observations. The quadrant has, however, of late years been entirely superseded by the *mural circle*; it having been found that the circle, on account of the symmetry of its form, and the advantage which it possesses of allowing the readings to be made at different parts of the limb, is an instrument much more to be relied on. [MURAL CIRCLE.] Hadley's *quadrant*, in its principle and application, is the same as the *sextant*, by which it has been superseded. [SEXTANT.] For further information respecting the quadrant, see Lalande, *Astronomie*, s. 2,311; Vince's *Practical Astronomy*; Pearson's *Practical Astronomy*; and the *Penny Cyclopædia*.

QUADRANT. In Geometry, the fourth part of a circle; an arc of ninety degrees.

QUADRANT. In Gunnery, an instrument occasionally used for regulating the elevation of pieces of ordnance. It consists of two bars of wood or brass, at right angles to each other, with an arc between them divided into degrees. A plumb line hangs from the angle at which the bars meet. One of the bars being placed in the bore of the piece, the degree on the arc intersected by the plumb line shows the elevation.

Quadrant of Altitude. An appendix to an artificial globe, consisting of a thin pliable slip of brass, which is applied to the globe, and used as a scale for measuring the distances between points in degrees. It is graduated into 90°, the degrees being of the same length as those on one of the great circles of the globe. At the end where the division terminates a nut is riveted on, and furnished with a screw, by which it is attached to the brass meridian of the globe at any point. This point being placed in the zenith, and the quadrant applied to the globe, its zero coincides with the horizon, and consequently the altitude of any point along its graduated edge is indicated by the corresponding division.

Quadrantal Triangle. In Trigonometry, a spherical triangle which has one side equal to a quarter of a circle, or 90°.

Quadratic Equation. In Algebra, an equation which involves the second, but no higher power of the unknown quantity. The most general form of a quadratic equation is

$$ax^2 + 2bx + c = 0,$$

where a, b, c, denote any positive or negative numbers. This is sometimes called an *adfected* quadratic, in order to distinguish it from the *pure* quadratic, whose form is

$$a'x^2 + c' = 0.$$

The solution of a pure quadratic is obvious; its two roots are $\sqrt{-\frac{c'}{a'}}$ and $-\sqrt{-\frac{c'}{a'}}$, both of which are real or imaginary according as a' and c' have unlike or like signs. To solve an adfected quadratic it is first reduced to the pure form. This may be done by first dividing the equation by the coefficient of x^2, and then adding and subtracting the square of half the coefficient of x. The above equation thus becomes

$$x^2 + 2\frac{b}{a}x + \frac{b^2}{a^2} - \frac{b^2}{a^2} + \frac{c}{a} = 0,$$

$$\text{or } \left(x + \frac{b}{a}\right)^2 = \frac{b^2 - ac}{a^2},$$

whose roots are obviously $\frac{-b + \sqrt{b^2 - ac}}{a}$ and $\frac{-b - \sqrt{b^2 - ac}}{a}$.

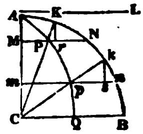
The sum of these roots is seen to be $-\frac{2b}{a}$ and their product $\frac{c}{a}$. This property is a general one [THEORY OF EQUATIONS], and from it is deduced the following simple rule for forming the quadratic whose roots are two given numbers. For the absolute term of the equation, take the product of the given roots, for the coefficient of x take the negative sum of these roots, and let x^2 have the coefficient unity. Thus the equation whose roots are 2 and -3 is

$$x^2 + x - 6 = 0.$$

The expression $b^2 - ac$, under the radical sign, is called the *discriminant* of the equation. When it has a positive value, the roots are real and unequal; when it vanishes, the two roots are real and equal; and when it has a negative value, these roots are impossible or *imaginary*. [DISCRIMINANT.]

Quadratic Form. [QUADRIC.]

Quadratrix. In Geometry, a transcendental curve, by means of which the quadrature of curvilinear spaces can be determined mechanically. The best known of these curves is the *Quadratrix of Dinostratus*, so called from its reputed inventor, a brother of Menechmus and disciple of Plato. This curve is generated as follows:—



In the circular quadrant C A B, suppose the radius C A to revolve uniformly about C, passing through the different positions C K, C k, &c., till it arrives at the position C B; and that during the same time a line A L, at right angles to C A, moves parallel to itself with a uniform motion from the position A L, through the different positions M N, $m\,n$, &c., so as to arrive at C B at the same instant that C K coincides with C B; then the continual intersection of the revolving radius and the parallel line will trace the quadratrix A P Q.

From this mode of describing the curve, it is easy to see how it may be applied to divide an angle into any number of equal parts. Let it be required, for example, to trisect the angle A C k. Having applied the quadratrix to C A, take A M equal to a third of A m, and through M draw M N perpendicular to A C, meeting the curve in P; join C P, and the angle A C P is equal to one-third of A C k; for by the nature of the quadratrix A M : A m : : A K : A k.

The application of this curve to the quadrature of the circle depends on the property that the line C Q is a third proportional to the quadrantal arc A B, and the radius. Hence the arc $AB = \frac{CB^2}{CQ}$, and consequently the area of the quadrant $CAB = \frac{CB^3}{2\,CQ}$.

If the quadratrix be continued beyond A, without the circle, it will consist of a series of infinite hyperbolic branches, cutting the axis C A produced, in points which are separated from each other by a space equal to 2 A C.

Other curves may be formed in a similar manner, by which the quadrature of the circle would be obtained. Thus, instead of supposing the lines M N, $m\,n$ to be intersected by the radiants C K, C k, we may suppose straight lines drawn from K k parallel to A C, intersecting M N, $m\,n$ in r and s; these intersections form a different curve, which is called the *Quadratrix of Tschirnhausen.*

Let $AM = x$, $MP = y$, and $AC = a$; then since $x : a :: AK : AB$, or $\frac{1}{2}\pi$, we have $AK = \frac{\pi x}{2a}$. Hence the equation of the quadratrix of Dinostratus is

$$y = (a - x)\tan\frac{\pi x}{2a};$$

and that of the quadratrix of Tschirnhausen is $y = a \sin\frac{\pi x}{2a}$. (Montucla, *Histoirè des Mathématiques*; Peacock's *Collection of Examples*; Leslie's *Geometry of Curve Lines.*)

Quadrats (Lat. quadratus, *squared*). In Printing, pieces of metal of the depth of the body of the respective sizes of types, and lower

than the types themselves, so that they leave a blank space on the paper when printed. An *en* quadrat is in thickness half the depth, an *em* equal in thickness and depth, a *two-em* quadrat twice the depth, &c. They are used to fill out short lines, form white lines, &c.

Quadrature (Lat. quadratum, *a quartering*). In Astronomy, this term denotes the position of the moon when she is 90° from the sun, or at one of the two points of her orbit equally distant from the conjunction and opposition.

QUADRATURE. In Geometry, this word signifies the determination of the area of a curve, or finding an equal square. The differential element of the area of a curve referred to rectangular coordinates is $y\,dx$; and since y is given in terms of x by the equation of the curve of which the area is proposed to be found, the problem of quadratures in general reduces itself to the integration of the differential $X\,dx$, in which X is an algebraic function of x and known quantities. In the applications of the higher geometry, a problem is conceived to be resolved when it is reduced to quadratures; i.e. when the variable quantities have been separated, and its solution been made to depend on finding the values of one or more integrals of the form $\int X\,dx$.

The *quadrature of the circle* is a problem of great celebrity in the history of mathematical science. The whole circular area being equal to the rectangle under the radius, and a straight line equal to half the circumference, the quadrature would be obtained if the length of the circumference were assigned; and hence the particular object aimed at in attempting to square the circle is the determination of the ratio of the circumference to the diameter. This ratio can be expressed only by infinite series, of which many have been given that converge with great rapidity. [CIRCLE.]

Pretenders to the discovery of the quadrature of the circle occasionally present themselves even at the present day. They are to be found only among those who have an imperfect knowledge of the principles of geometry; and when their reasoning happens to be intelligible, their paralogisms are in general easily detected. With a view to discourage the futile attempts so frequently made on this and similar subjects, the Academy of Sciences of Paris, in 1775, and the Royal Society shortly after, publicly announced that they would not examine in future any paper pretending to the quadrature of the circle, the trisection of an angle, the duplication of the cube, or the discovery of the perpetual motion. For the history of this famous problem, see the third supplement to the fourth volume of Montucla.

Quadri-hydrocarbon. A liquid hydrocarbon of the same chemical constitution as olefiant gas, and containing eight atoms of carbon united with eight atoms of hydrogen. Formerly it was supposed to contain only half this number of atoms of each element. Hence the name.

Quadric. In Algebra, a homogeneous expression of the second degree in the variables or facients. [QUANTIC.] Ternary and quaternary quadrics, equated to zero, represent respectively curves and surfaces which have the property of cutting every line in the plane or in space in two points, and to which the name *quadric* is also applied. Plane quadrics, therefore, are identical with the conic sections, and admit of three principal forms, the *ellipse*, *hyperbola*, and *parabola*; subforms of which are the *circle*, a pair of *intersecting*, and a *pair of coincident lines*. [CONIC SECTIONS.] The ellipse is characterised as being a closed curve, the hyperbola as having two distinct points at infinity, and consequently two real asymptotes, and the parabola as having two coincident points at infinity, and therefore an infinitely distant tangent. A plane quadric may also be regarded as the locus of the intersections of corresponding rays of two homographic pencils [PENCIL], or as the envelope of the line joining corresponding points of two homographic divisions. [HOMOGRAPHIC.] The envelope in the last case can easily be shown to be of the second class. For if a and a_1 be two corresponding points on the homographically divided lines A and A_1, and o any other point in the plane, $o\,a$ and $o\,a_1$ will clearly be corresponding rays of two concentric pencils, which latter will, of course, have two *common rays*; so that of the tangents $a\,a_1$ to the envelope two will in general pass through an arbitrary point o. To prove that such an envelope of the second class is also a quadric or curve of the second order, it is necessary to show that two pairs of consecutive tangents intersect at two points of a given arbitrary line L. To do so, conceive any point m on L, and let the two tangents through m cut A in a and α; then as m changes, a and α will clearly determine an involution of the second order on A [INVOLUTION], which will of course possess two double points, to which will correspond on L two distinct intersections of consecutive tangents, in other words two points on the envelope. Since a plane can always be drawn through three points of a non-plane curve, it is manifest that there are no non-plane quadric curves.

Quadric surfaces are classified in various ways. The *central quadrics*, or those which have centres, are the *ellipsoid* and the *hyperboloids* of one and two sheets, respectively, to which may be added the *cone*. The *non-central quadrics* are the *elliptic* and *hyperbolic paraboloids*, to which may be added the several *cylinders*, distinguished as *elliptic*, *hyperbolic*, or *parabolic*, according to the nature of their sections. All plane sections of the ellipsoid are ellipses, and those of the hyperboloids are either ellipses or hyperbolas. The paraboloids, besides having plane parabolic sections, have either elliptic or hyperbolic ones, and are named accordingly. Besides the cone and cylinders there are two quadric *ruled surfaces*,

the hyperboloid of one continuous sheet, and the hyperbolic paraboloid, each of which may be generated by a line which moves so as to rest on three rectilinear directrices which do not intersect one another. [Ruled Surface.] If the three directrices are parallel to one and the same plane, then the generator will always remain parallel to another plane, and the generated quadric will be a hyperbolic paraboloid; in other cases it will be a hyperboloid. If the two planes, to which the directrices and generator are respectively parallel, be at right angles to each other, the paraboloid is said to be *equilateral*; it is in fact a *conoid* surface, since it may be generated by the motion of a line resting on two directrices to one of which it is always perpendicular. [Conoid.] Every plane through a generator of a quadric ruled surface meets the latter in a second line, and touches it at the point where the lines intersect each other; so that at every point of a ruled quadric a straight edge can be applied to the surface in two distinct directions, and the whole surface is filled, as it were, by two systems of lines or *generators* such that each generator meets no generator of its own system, but cuts every generator of the other system. The distinctive character of the paraboloid is that one generator in each system is infinitely distant. In the hyperboloid the generators are all parallel to those of a quadric cone, the *asymptotic cone*; in the paraboloid they are parallel to a system of two planes, the *asymptotic planes*. Ruled quadrics may also be regarded as the locus of the line which joins corresponding points of two homographically divided lines not in the same plane. If the lines are divided proportionally the quadric will be a paraboloid; or lastly a ruled quadric may be regarded as generated by the intersections of corresponding planes of two homographic pencils whose axes are not in the same plane. From these modes of generation it is at once evident that every plane cuts the generated surface in a quadric curve, and that the tangent planes through any point in space envelope a quadric cone; in other words, that the surface is of the second order and second class.

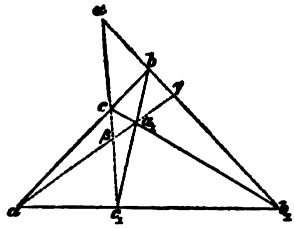
Quadric Cone. A cone of the second order. [Cone.]

Quadricorns (Lat. quatuor, *four*; cornu, *a horn*). A family of Apterous insects, comprehending those which have four antennæ. A species of Antelope with four horns is called *Antilope* (*Tetracerus*) *quadricornis*.

Quadrifores (Lat. quatuor, and foro, *I pierce*). A name given by Latreille to a family of sessile Cirripeds, comprehending those in which the opercular covering of the tube is composed of four valves or calcareous pieces.

Quadriga (Lat. contracted from quadrijuga, *a team of four animals*). In Roman Antiquities, a car or chariot drawn by four horses, which were harnessed all abreast, and not in pairs. The quadriga is often met with on the reverse of medals, which are thence termed *nummi quadrigati* or *victoriati*, as exhibiting a representation of a figure of Victory holding the reins.

Quadrilateral (Lat. quadrilaterus, *of four sides*). In Elementary Geometry, a plane figure contained by four straight lines. Such a figure has four angles or corners, and is consequently also a *quadrangle*. The lines joining its oppo-



site corners constitute its *two diagonals*. In modern geometry, however, a *quadrilateral* or *tetragon* denotes a system of four lines (sides); whilst by *quadrangle* is usually meant a system of four points (angles). The former has six angles or points in two sides, and the latter has six sides or lines through two points. If the full lines in the figure represent any *complete quadrilateral*, the broken lines $a\,a_1$, $b\,b_1$, $c\,c_1$, joining the three pairs of opposite angles, constitute its *three diagonals*. One of the most important properties of a complete quadrilateral is that each diagonal is cut by the other two in harmonic conjugates with respect to the two angles which it contains. Thus a, a_1, β, γ; b, b_1, γ, α; c, c_1, α, β, are four sets of harmonical points.

Four lines in space, two of which, though not in the same plane, are intersected by each of the others, form a *skew quadrilateral*.

Quadrilateral. This name has been used, in the recent struggles between the Italians and the Austrians, to denote the territory, which forms a sort of square, between the fortresses of Peschiera, Verona, Legnano, and Mantua.

Quadrilaterals. The name of a tribe of crabs (Brachyurous Crustaceans), comprehending those in which the carapace or shell is more or less square-shaped.

Quadrille (Fr.). A game at cards for four persons, having some resemblance to whist. It was very popular and fashionable in England some two generations back, but is now almost f rgotten. It ought to be revived, for it has reat merits. It demands less science, thought, and memory than whist; but still it gives ample scope for skilful play, and it is much more varied, amusing, and suitable for younger players. It is a highly original game, having some peculiar features, and therefore requires a little attention from beginners; but the peculiarities are soon mastered, and are easily remembered.

Quadrille is played with a pack of forty cards, the eight, nine, and ten of each suit being rejected. The dealing and order of playing are similar to whist; except (1) that they go the *contrary way round*, the person at the right of

the dealer being elder hand; (2) that the cards must be dealt in parcels of twos, threes, and a four to each person, and not singly; and (3) that no trump is turned up, the trump suit being determined in another way. It is advisable not to shuffle the cards between the deals, but merely to cut them.

The order of value of the cards is peculiar, being different in the two colours, and being also quite exceptional in regard to the suit of trumps. For suits *not trumps* the order is as follows:—

Red Suits	*Black Suits*
King (highest)	King (highest)
Queen	Queen
Knave	Knave
Ace	—
Two	Seven
Three	Six
Four	Five
Five	Four
Six	Three
Seven (lowest)	Two (lowest)

For the *trump* suit the order of value is as follows:—

First comes the ace of spades, which, *whatever be the trump suit*, is always ranked as the best trump card, and is called *spadille*.

Second in rank comes what would be the lowest card if the suit were not trumps, i. e. the seven if red, and the two if black; this is called *manille*.

Third comes the ace of clubs, which, whatever be the trump suit, is always ranked as the third best trump card, and is called *basto*.

Fourth, if the trump suit be red, comes the ace of the trump suit, called *ponto*; if black, there is no ponto.

After these come the other cards of the trump suit in their usual order, so that the complete suit of trumps is as follows:—

If Red	*If Black*
Ace of spades (*spadille*)	Ace of spades (*spadille*)
Seven (*manille*)	Two (*manille*)
Ace of clubs (*basto*)	Ace of clubs (*basto*)
Ace (*ponto*)	King
King	Queen
Queen	Knave
Knave	Seven
Two	Six
Three	Five
Four	Four
Five	Three (lowest)
Six (lowest)	

It will be seen that there are twelve trumps when the suit is red, but only eleven when black.

The three best trump cards, with the special names, are called *matadores*, or shortly *mats*. They have the privilege that the holder is not bound to follow suit with them when trumps are led, except when the card led is a higher mat, which forces a lower one, if there is no other trump in the hand.

The cards being dealt round, and the players having examined their hands, a decision is come to about trumps and partners in the following manner.

The elder hand has the first option of nominating trumps and playing for the game; and he has also the power of deciding whether he will play alone against the other three, or will take a partner. His choice will be regulated by the nature of his hand.

First, let us suppose he has a very strong hand in one particular suit, say diamonds, and has also other good cards, so as to be able by himself to make *six tricks*, which is the object of the game; he says, 'I play alone with diamonds for trumps,' or, 'I play alone in diamonds.' From this there is no appeal, and the game proceeds on his proposition.

But secondly, suppose he has a moderately strong hand in one suit, so that he can probably make *four tricks*, he decides to take a partner to help him by getting two, and he then says, 'I ask leave' (to take a partner). Now, if the second hand, or after him the third or fourth hand, choose to *stand alone* in any suit, they take precedence over the first hand's 'ask leave;' giving *him*, however, the previous option of standing alone if he pleases. If no one makes this proposition, the elder hand, having thus obtained the *leave* he asked, names his trump suit, and calls, for his partner, the player who may hold the *king* of any suit, not trumps, which he chooses to name; he says, for example, 'I make diamonds trumps, and call the king of spades.' The player who holds this card then knows that he is the partner chosen, although he must not reveal this fact except by his play; the other two, of course, know they are opponents, and regulate their play accordingly. If the caller happens to hold all *four* kings in his hand, he may call a queen.

The third alternative for the elder hand is that in which he may have but poor cards, not sufficient to warrant him in playing for the game either alone or with a partner; in which case he says, 'I pass,' and waives his privilege, which passes on to the second player, and from him to the third and fourth in turn. The one who ultimately undertakes the game, and nominates trumps, is called the *ombre*. If the cards are pretty equally divided, all the players may *pass*; and then the one who holds spadille is *forced* to be ombre, and to nominate trumps, calling a king in the usual way. This is called *forced spadille*. Some authorities, however, object to forced spadille, and prefer a fresh deal.

The trumps and partners being decided, play begins for tricks in the same manner as in whist, and subject to the same rules, except as before stated. The elder hand (to the *right* of the dealer) leads first, and the winner of each trick leads for the following one. The object is to win six tricks, called *game*, which *ombre*, either alone or with a partner, undertakes to do; if he makes less, he is said to be *basted*, and has to pay a forfeit, as hereafter explained.

When six tricks have been won by either party, the play is discontinued, unless the winners should choose to undertake to make *all* the ten tricks, which is called *vole*. A player alone would, of course, decide this himself; but if there are partners, the winner of the sixth trick tells his partner how many more tricks he thinks he can make, and the latter then decides whether they will venture it or not. If it is undertaken and not obtained, the parties are punished by forfeits.

Each deal of cards constitutes a complete game.

The game is played with a pool. Each player is furnished with a little tray, and the large tray, or pool, is managed by any one of the four who will undertake it; this being, however, merely a matter of convenience, involving no speculation or risk. The players subscribe equally, on commencing, to form a common fund, which is put into the pool; and, as it is not always convenient to be handing about small *coins*, it is customary to exchange a portion of the fund for counters, which have a certain definite value, and are convertible back again into money at any time throughout the play. When the pool is thus made up, a number of counters are distributed to the players equally, say six to each, to enable them to meet certain payments they may perhaps have to make. We shall take one counter as the constant unit of value.

The transactions are of three kinds—payments from the pool, forfeits to the pool, and payments between the players.

1. The *payments from the pool* are ordinarily *seven counters* each game, viz.

One counter to the holder of each of the red aces.

One counter to the holder of each matadore.

Two counters for winning the game; divided, if won by partners.

2. The *forfeits to the pool* are founded on a principle universally applicable in quadrille, that whoever fails to win what he undertakes must forfeit the sum which he would have obtained if he *had* won; the undertaking being considered in the light of a *wager*. Thus:—

If *player alone* be basted, i.e. make less than six tricks, he forfeits to the pool two counters. If he make only four, the adversaries win; and as *each* of the three is supposed to be equally instrumental in winning, each is accordingly paid one counter from the pool.

If ombre and partner be basted, i.e. make together less than six tricks, two counters are forfeited in like manner to the pool, which must be paid by ombre alone, he being assumed to be the party at fault. If they make only four tricks, the opponents, winning the game, receive from the pool the payment forfeited by ombre.

The mats and red aces are always paid for to the holders, no matter how the game goes.

3. The *payments between the parties*, which are quite distinct and separate from the pool transactions, are as follows:—

If *player alone* win the game, he receives two counters from each of his three adversaries. If he fail to win it, he *pays* two to each.

If *player alone* hold all the three matadores, and win the game, he receives one counter additional from each opponent; but if he fail to win, he *pays* one to each.

If ombre and partner hold between them all the three matadores, and win the game, they each receive one counter from one adversary; if they fail to win, they each *pay* one counter in like manner.

The *vole* is entirely a separate speculation from the game, the rewards and forfeits for it being arranged as follows: If the vole is played for, and won, by two partners, each receives two counters from the pool, and two from one of his adversaries; if lost, the undertakers forfeit to the pool and the adversaries a like sum. If the vole is won by a *player alone*, he is paid four counters from the pool and two by each adversary; if lost, he pays like sums.

We will now give an example of a game for practice and illustration.

An ask leave in a red suit.—Eldest hand has—*Clubs*: queen, knave, six, five; *hearts*: ace; *spades*: six, two; *diamonds*: five, four, two.

Second hand has—*Clubs*: ace; *hearts*: queen, knave, seven, four; *spades*: king, three; *diamonds*: ace, queen, three.

Third hand has—*Clubs*: king, four, three, two; *hearts*: six, five, two; *spades*: queen, knave; *diamonds*: knave.

Fourth hand (the dealer) has—*Clubs*: seven; *hearts*: king, three; *spades*: ace, seven, five, four; *diamonds*: king, seven, six.

First hand passes; his longest suit is clubs, but in that he has the three mats and king against him. In spades he has manille; but that alone, or with one other only, cannot be calculated upon for a trick.

Second hand asks leave in hearts, having manille, basto, queen, knave, and four. He allows for manille falling to spadille, and will make basto, that is one trick. With queen, knave, and four, he must make one, probably two more tricks. The king of spades is a third, and the queen of diamonds is a fourth trick. In order to establish his queen of diamonds, he will *call* the king.

Neither third nor fourth hand can play alone, as it will easily be seen that in no suit could either of them make six tricks; they therefore pass.

The second hand now says, 'I play in hearts, and call the king of diamonds.' Consequently, his partner is the fourth hand.

The lead being with No. 1, he leads a club, say the five; as he has four, he hopes that if ombre (that is, No 2) has the king, his (No. 1's) partner (No. 3) may trump it. At all events, No. 1 will establish his queen and knave of clubs. Ombre sees at once that No. 1 is an adversary; had he been his partner, he would have shown himself either by leading trump, or the called king (diamonds). Ombre, therefore, trumps with the four. No. 3 throws the two, No. 4 the seven.

Ombre now leads the three of diamonds to discover his partner. No. 3 throws the knave; No. 4 the king, discovering himself; No. 1 throws the five, being the worst diamond in his hand.

No. 4 now leads the three of trumps. This play shows ombre that he has a mat, and ombre knows it to be spadille as he himself holds manille and basto. No. 1 is forced to follow suit with ponto; ombre plays basto; No. 3 throws the six.

Ombre leads manille; No. 3 throws the five No. 4 the king; No. 1 small spade.

Ombre, queen of trumps; No. 3, the two; No. 4, seven of diamonds (spadille, in common with other mats, possessing the power of holding up); No. 1, the four of diamonds.

Ombre, knave of trumps; No. 3, three of clubs; No. 4, six of diamonds; No. 1, six of clubs.

The game is now won. The question remains whether ombre and his partner can play the vole. Now ombre knows his partner has spadille, that is, one trick; he himself has three more certain tricks in his hand; he therefore declares to play vole, as follows:—

Ombre, queen of diamonds; No. 3, anything; No. 4, anything; No. 1 follows suit.

Ombre, ace of diamonds; Nos. 3, 4, and 1, anything; ombre, king of spades; Nos. 3, 4, and 1, anything; and spadille must make remaining trick.

As to the payment:—

No. 1 receives from the pool one counter for his ace of hearts; he has to pay to one of his adversaries one counter for their possessing all the mats, and two counters for their playing the vole.

No. 2 (ombre) receives from No. 1 or 3 one counter for mats, and two for vole. From the pool one counter for red ace, one for manille, one for basto, one for game, and two for vole.

No. 3 pays as No. 1.

No. 4 receives from 1 or 3 as No. 2; from pool, one counter for spadille, one for game, two for vole.

What we have above described is the simple game, but it is very customary to play it with a slight modification, called *preference*. In this, one suit, namely hearts, has a preference in the nomination of trumps; thus, if the elder hand has asked leave, the second hand (or after him the third or fourth) may ask him 'if it is in hearts,' and if he says no, the other may ask leave by *preference* in hearts, which takes precedence accordingly. But it must be borne in mind that *standing alone* in any common suit always take precedence of an *ask leave* in the preferred one.

In playing preference, all payments, rewards, and forfeits, are *doubled* when hearts are made trumps.

Sometimes there is a *double* preference, clubs (then called *mogul*) being preferred over hearts, and when these are trumps all payments are quadrupled.

It is also very common to have the option of *purchasing a king*. It may often happen that a player finds that the possession of a certain king, which he has not, would enable him to *play alone*. In this case he may purchase it from the party holding it, giving one counter in payment (subject to increase for preference), and any card which he can best spare from his hand. But if he then win the game he only receives from his adversaries one counter each, instead of two.

We advise the adoption of single preference, and the purchased king, as giving additional interest and variety to the game, without adding to its difficulty.

The celebrated game described in Pope's *Rape of the Lock* was a modification of Quadrille.

Quadrinvariant. [INVARIANT.]

Quadripennates (Lat. quatuor; penna, *a wing*). The name of a section of Anelytrous insects, including those which have four wings.

Quadriplanar Coordinates. [COORDINATES.]

Quadrireme (Lat. quadriremis, from quatuor, and remus, *an oar*). A ship of war in use among the ancient Greeks and Romans; so called because it had four banks of oars. [GALLEY.]

Quadrisulcates (Lat. quatuor, and sulcus, *a furrow*). A name applied to those Ungulate quadrupeds in which the hoof is divided into four parts, corresponding to the four digits of the Artiodactyle foot.

Quadrivium (Lat.). In the language of the schools, the four lesser arts—arithmetic, music, geometry, and astronomy. (Hallam, *Literary History*, pt. i. ch. i. § 3.) [TRIVIUM.]

Quadrumana (Lat. quatuor, *four*, and manus, *hand*). The name of an order of Mammals, comprehending those in which the four extremities are terminated by a hand; as the ape, baboon, &c. The hinder extremities are always terminated by more perfect hands than the fore extremities, in which the thumb is sometimes wanting, or, as in the South American monkeys, incapable of being opposed to the other digits.

Quadrupeds (Lat. quadrupes, from quatuor *four*, and pes, *a foot*). All Vertebrate animals with four extremities fitted for terrestrial progression were formerly so called, the scaly reptiles being distinguished, as oviparous quadrupeds, from the hairy warm-blooded viviparous four-footed mammals. But as there are both reptiles and mammalia which have only two legs, and as those of both classes which agree in having four legs differ essentially in the important characters on which classificatory distinctions are now founded, the term *quadruped* is no longer used in a strict zoological sense as indicative of a particular group of animals.

Quadruple (Lat. quadruplus). In Arithmetic, fourfold; the product of any magnitude or quantity multiplied by 4.

Quæstor (Lat.). In Roman Antiquities, the name of two distinct classes of public officers.

According to Varro, they were so called 'a quærendo, qui conquirerent publicas pecunias et maleficia.' The former, who collected the public revenues, were called *quæstores classici*; the latter, as public accusers or prosecutors in criminal cases, were known as *quæstores parricidii*. At first, like other offices, the quæstorship was confined to the patricians, and only after a severe struggle laid open to the plebeians; but beyond this broad fact, nothing can be determined with certainty from the traditions embodied in the writings of non-contemporary historians. According to some writers, two quæstors were for the first time appointed during the consulship of Valerius and Lucretius, soon after the expulsion of the kings, while others speak of the office as having existed under the kings. But all these writers agree in describing the office as one open only to patricians, and as continuing so until L. Papirius, B. C. 420, brought about a compromise on the arrangement that consular tribunes should be elected instead of consuls, and that four quæstors should be chosen promiscuously from patricians and plebeians, the singular result being that all the officers elected were patricians, and that no plebeian was elected quæstor for eleven years after this time. An altogether different account is given by Tacitus, who says that they were chosen first by the kings, then by the consuls, the election being afterwards transferred to the people, by whom the first military quæstors were appointed, the civil quæstorship being afterwards instituted for the business at Rome when the military quæstors were found unable to deal with it. 'It is impossible to reconcile any part of this account with the representation in Livy. Neither the transfer of the appointment from the consuls to the people, nor the time when the first quæstors were elected, nor the priority of the military to the urban prætors, agrees with Livy's statements. In this as in other cases, the accounts of the origin of an ancient institution, given by different writers, are wholly irreconcilable.' (Sir G. C. Lewis, *Credibility of Early Roman Hist.* ii. 286.)

Quagga. The name of a Solipedous quadruped, or species of *Equus*, allied to the zebra.

Quagmire. Boggy ground saturated with water to such a degree as to be more like mud than firm soil.

Quail (Ital. quaglia, Fr. caille). A genus of Gallinaceous birds (*Coturnix*, Cuv.), allied to the partridge, but of smaller size, with a more slender beak and shorter tail, and without red eyebrows or spurs.

Quakers or **Friends.** A religious sect, which arose in England about the middle of the seventeenth century, and spread, by the emigration of its members, who were exposed to many restrictions and to persecution in this country, over various parts of Europe and North America. Its founder was George Fox, who, being equally dissatisfied with the tenets of the established church and those of the Puritans, attached to himself various persons who agreed with his view of the internal operation of religion on men's hearts, conceiving it to supersede all ritual observances, and to be in no degree evidenced by them. The Quakers, therefore, reject all sacraments; nor do they appoint an order of ministers, but consider that the instruction of their congregations may be from time to time undertaken by any person of either sex who feels impelled thereto by a suggestion of the Spirit. Upon doctrinal points, however, they profess to maintain the opinions generally received by Christian churches and sects.

This society is distinguished in its intercourse with the world by great seriousness of deportment, uniform soberness in dress, and generally by a scrupulous avoidance of everything which can encourage vanity and frivolity. They are averse from all matters of ceremony, which they conceive to have their origin in flattery and deception. Their refusal to take judicial oaths used formerly to subject them to severe penalties. Up to the accession of James II. their history is a series of persecutions, either endured in common with other dissenters, or peculiar to themselves in consequence of their refusal to pay tithes and to take oaths. Under James, the severity of the penal laws was relaxed; William Penn, one of the earliest Quakers, the founder of Pennsylvania, having been one of that monarch's confidential advisers, or, as some say, tools, in that matter. But William III. was the first prince who enacted laws for their special relief. Under his reign their affirmation was received in lieu of oath in judicial proceedings; a privilege since extended by various Acts to Moravians, Separatists, and persons who have left those societies but retain conscientious scruples to taking an oath. (Fox's *Journal*; Barclay's *Apology*; and Sewell's *History of the Rise, &c. of the Quakers*, 1722.) The Quakers of the present day are thought to be a decreasing sect. In 1800 they possessed 413 meeting houses, while the number returned in 1851 was only 371. They are most numerous in Yorkshire, Lancashire, Durham, Cumberland, and Essex. Small communities are found in parts of France, Germany, Norway, the United States, and Australia. (*Religious Census* 1851.)

Quaking Bog. Peat bog in a growing state, and so saturated with water that a considerable extent of surface will quake or shake, when pressed on by the foot or any other body. Such bogs are unfit for any useful purpose till they are drained.

Quality (Lat. qualitas, from qualis, *of what sort*). In the philosophy of Kant, the *second* category (there being four in all), comprising the notions of existence or reality, nonexistence or negation, and limitation.

Quality. In Logic, a division of propositions, founded on their affirmative or negative character.

Quality. In Physics, some property or affection of bodies. Sensible qualities are those which immediately affect the senses; as figure, taste, &c.

Quantic (Lat. quantus, *how great*). In its widest sense this term denotes a rational and

integral algebraical function. As, however, all such functions may be supposed to have resulted from the substitution of unity in place of one of the variables of a homogeneous function, a quantic is usually understood to denote any rational integral homogeneous function. The term, which is both convenient and expressive, was introduced by Cayley, and is now in general use amongst English mathematicians. The especial terms *quadric, cubic, quartic, quintic,* &c. . . n^{ic} are used to denote quantics of the *second, third, fourth,* &c. . . n^{th} degrees in the variables, and as a further distinction, quantics are said to be *binary, ternary, quaternary,* &c. . . n-ary according as they contain *two, three, four* &c. . . or n variables. Thus a *ternary quadric* denotes a rational integral and homogeneous function of the fourth degree in three variables or facients. According to the ordinary notation of algebra, the most general form of such a function would be denoted by

$$ax^2 + by^2 + cz^2 + dyz + ezx + fxy,$$

and according to the notation of quantics by

$$(a, b, c, d, e, f, \overset{\leftarrow}{\between} x, y, z)^2,$$

or more simply by

$$(^*\between x, y, z)^2$$

when it is wished to indicate rather than to express the coefficients. The arrow-head in the above symbol denotes the *absence* of expressed *numerical* coefficients in the ordinary expression of the quantic. In operating upon quantics, however, it is usually more convenient to assume a different general form, and

$$(a, b, c, d, e, f \between x, y, z)^2$$

denotes that the several terms of the quadric are affected with the same numerical coefficients as are the like terms in the developement of $(x+y+z)^2$. [MULTINOMIAL THEOREM.] The trilinear equation of a curve, or the quadriplanar one of a surface being a quantic, the terms *quadric, cubic,* &c. . . . are also applied to curves and surfaces of the second, third &c. . . orders respectively. Prof. Cayley's original memoirs on Quantics will be found in the *Philosophical Transactions* for 1854 and subsequent years.

Quantity (Lat. quantitas). A property of anything capable of being increased or diminished. Quantity is distinguished into *continued* and *discrete.* It is continued when the parts are connected together, and is then called magnitude, which is the object of geometry. It is discrete when the parts have an unconnected and independent existence, forming multitude or number, which is the object of arithmetic. The quantity of matter in a body is termed its MASS; the quantity of motion it possesses its MOMENTUM.

QUANTITY. In Logic, the extent to which the predicate in a proposition is asserted of the subject. If it be asserted of the whole (all, none), the proposition is universal. If it be asserted of part only (some), the proposition is particular. A singular proposition is regarded as universal.

QUANTITY. In Prosody, the amount of time in a syllable. Syllables are either short or long; the former being the unit or smallest measure of time, the latter consisting of two times. This distinction is clearly marked in the ancient languages; in which some syllables are necessarily long or short by position, others by the nature of the vowels which they contain, and some common, or susceptible of being sounded as long or short, according to certain rules of elegance or convenience. The whole metrical system of the ancient languages is founded on quantity. In most modern languages there is, strictly speaking, no quantity, as distinct from emphasis, or accent; the long syllables being those which receive the arsis, the short those which receive the thesis. In the German language, however, critics have endeavoured to establish a conventional system of quantity, and thus to adapt that language to regular versification in the ancient Greek and Latin metres. [RHYTHM; METRE.]

Quaquaversal Dip (Lat. quaqua, *wheresoever,* and versus, *turned*). When deposits have been lifted up by elevatory force acting at a single point, they assume a dome-like form, and the beds dip in every direction from this central elevated point. Such dip is called *quaquaversal.* [DIP AND STRIKE.]

Quarantine. A period of time of variable length, during which a vessel from certain coasts or ports, said or supposed to be infected with certain diseases, is not allowed to communicate with the shore, except under particular restrictions. A ship in quarantine carries a yellow flag at the main; and when released from this condition, she is said to obtain *pratique.* The term is derived from the Ital. quaranto, *forty,* it being generally supposed that if no infectious disease break out within forty days or six weeks, no further danger is to be apprehended. It is believed that the Venetians were the first to adopt regulations for guarding against the introduction of infected persons into their ports; but there is now no civilised country in which it is not more or less practised. Of late years the rapidity of steam communication, the great improvement in the sanitary condition of the people, the progress of chemical science, which has led to the discovery of powerful disinfectants, and perhaps the scepticism with which many received opinions on the subject of infection have been encountered by some physiologists, have led to the gradual relaxation of quarantine laws; and now, although the power to impose it rests with the crown, quarantine is rarely demanded in British ports. (For full particulars on the history and policy of quarantine, see the *Com. Dict.*)

QUARANTINE. In Law, the forty days during which a widow is, by Magna Charta, entitled to reside in her husband's capital messuage after his death. During this time her dower shall be assigned. [DOWER.]

Quare Impedit (Lat.). In Law, the ordinary action to establish the right of a patron to present to an ecclesiastical benefice when

his title to do so is disputed. The action is brought in the Court of Common Pleas. The procedure relating to it has recently been simplified by stat. 23 & 24 Vict. c. 126.

Quarrel (Mod. Lat. quadrellus, Fr. carreau). The arrow or bolt for the crossbow in mediæval warfare. The word is derived from the four-sided pyramidal form of the head.

Quarrying (Fr. carrière). The process of removing valuable mineral produce from the earth when it can be got at without sinking pits or driving tunnels into the interior. It is generally the mode adopted for obtaining marble, building stone, road metal, slate, chalk, &c., but is occasionally adopted for metalliferous minerals and coal. Large quarries of ironstone are worked in the isle of Elba, near Malaga in Spain, and in many other places. Coal has often been quarried in England, and is generally so obtained from some of the thick beds in the centre of France. On the other hand, many valuable stones are obtained by tunnels. This is the case on a very large scale with the Bath and Caen stones.

The first operation in quarrying is to remove the head of rubbish and vegetable soil, and it is evident that for this, and for the placing of such waste material as may be produced in quarrying, either a large space is needed or these matters must be got rid of in some other way. Many quarries are opened on hill-sides and on cliffs near the sea, there being in either case conveniences for removal of waste.

In working a quarry extensively it is usual to work in several stages one above another. In this way many hundred men can be employed at once. For removing the stone, blasting is generally resorted to. This involves some danger, and shelter for the men during a blast is very desirable. Slate affords the largest and most valuable quarries in the world.

Quart (Lat. quartus, *fourth*). A measure of capacity, being the fourth part of a gallon. The word was also used during the middle ages to denote the fourth part of the tun, i.e. 63 gallons. [MEASURES.]

Quartan (Lat. quartana, sc. febris). A species of intermittent fever or ague. The interval between the attacks is only two whole days, nosologists having chosen to reckon the day of attack and the day of recurrence, so counting four days, and giving the name accordingly. [AGUE.]

Quartation. This term was formerly applied to the separation of silver from gold by means of nitric acid. To extract the whole of the silver from gold by the action of nitric acid, it is necessary that there should be at least three parts of silver to one of gold, otherwise the gold protects the silver from the action of the acid; so that, in thus separating these metals, it was customary where gold greatly predominated to add silver till it constituted at least three-fourths of the alloy. This separation of gold from silver is now effected by sulphuric acid.

Quarter (Lat. quartus). The fourth part of anything. As a term of weight, this word denotes the fourth of a hundredweight, or twenty-eight pounds.

QUARTER. As a dry measure, *quarter* is a term apparently of foreign origin, and probably Norman. It is uncertain whether it is the fourth part of some measure which has been long disused, or whether the word is connected with a division of land also known by the name. (Ducange.)

QUARTER. The after part of the ship's side, comprising about one-fifth of her total length. *On the quarter*, implies the bearing or position of an object seen between aft and abeam.

Quarter Days. The days usually regarded in England and most Continental countries (but not in Scotland) as beginning the four quarters of the year. They are: 1. Lady Day (March 25); 2. Midsummer Day (June 24); 3. Michaelmas Day (September 29); and 4. Christmas Day (December 25).

Quarter Deck. The portion of the uppermost deck of a ship between the main and mizen masts when there is a poop, but when there is no poop extending from the mainmast to the stern. This is the *parade* in men-of-war.

Quarter Round. In Architecture. [ECHINUS; OVOLO.]

Quarter Sessions of the Peace. In Law, a court held by two justices at least, one of whom must be of the quorum, quarterly, in every county. Its jurisdiction, originally confined to matters touching the breach of the peace only, has been extended by various statutes too numerous to be cited here. The criminal jurisdiction is principally defined by stat. 5 & 6 Vict. c. 38, and may be said to extend generally to the smaller misdemeanours and felonies, but with numerous exceptions. There is also an extensive jurisdiction in matters relating to the settlement and relief of the poor, highways, bastardy, &c., in most of which cases an appeal lies to the Court of Queen's Bench. [JUSTICES OF THE PEACE.] The administration of the county rates also belongs to the quarter sessions. Quarter sessions in boroughs, since the Municipal Corporation Act, are held by the recorders.

Quarter Sights. In Gunnery, sights on the sides of a smooth-bored gun, consisting of notches on the base ring, the lowest of which forms, with a notch on the side of the swell of the muzzle, a line parallel to the axis, the others forming lines inclined to the first at angles from fifteen minutes to three degrees.

Quarters. The stations of a ship's crew in time of action, to which they are summoned by beat of drum, or by the boatswain's pipe.

QUARTERS. In Military language, the room or rooms in barracks, or house, being government property, allotted to an officer for his accommodation.

Quarters and Quartering (Fr. quartiers). In Architecture, the upright posts in partitions to which the laths are nailed. Quarters are either single or double, the former being of sawn stuff four inches broad, and two and a

half or two inches in thickness; the latter being usually sawn to a scantling of four inches square. No quarters should ever be more than fourteen inches apart from out to out, even when the spaces between them are filled in with what is called *brick nogging*. Quartering is a term properly applied only to an assemblage of quarters, though it is not unfrequently used to denote the quarters themselves.

Quarter-master. In the Army, an officer whose business it is to look after the *quarters* of the soldiers, and attend to their clothing, rations, ammunition, &c. There is a quarter-master attached to every regiment of cavalry, battalion of infantry, or brigade of artillery.

QUARTER-MASTER. In the Navy, a petty officer, who, besides other duties of superintendence over the stowage of ballast, provisions, &c., attends to the steering of the ship.

Quarter-master-General. One of the chief staff officers of the army. His department is charged with all orders relating to the marching, embarking, disembarking, quartering, billeting, and cantoning of troops; encampments, and camp equipage. There are assistant and deputy-assistant quarter-master-generals of divisions and districts.

Quarter-staff. A weapon of defence; so called from the manner of using it, one hand being placed in the middle, and the other equally between the middle and end.

Quartering. In Heraldry, the division of a shield by two lines, fess-wise and pale-wise, meeting in the centre of the shield. In marshalling, whenever a husband can place his wife's arms on an escutcheon of pretence [ESCUTCHEON], the children may bear them quarterly with their own: whence arises the great variety of quarterings in the shields of some families.

Quartette or **Quartet** (Ital. quartetto). A piece of music arranged for four solo voices or instruments. Of the latter the most celebrated are arranged for two violins, a viola or tenor violin, and a violoncello; and many of the most distinguished composers, among whom we may mention Haydn, Mozart, Beethoven, Romberg, Spohr, Ries, Onslow, &c., have devoted their talents to this species of composition.

Quartic. In Algebra, a homogeneous function of the fourth degree in the variables or, as the latter are sometimes termed, facients. [QUANTIC.] Binary, ternary, and quaternary quartics have been most studied, in consequence of their connection, respectively, with the theories of equations, of curves, and of surfaces.

A *binary quartic*

$$(a, b, c, d, e)(x, y)^4,$$

put equal to zero, gives rise to a biquadratic equation in $\frac{x}{y}$. Its canonical form is

$$x^4 + 6mx^2y^2 + y^4,$$

and since the equation corresponding to the latter may be solved as a quadratic, the solution of a biquadratic equation obviously resolves itself into the reduction of the general quartic to its canonical form. This requires, as will be seen, the solution of a cubic. [BIQUADRATIC EQUATION.] The two fundamental invariants of the quartic are

$$S = ae - 4bd + 3c^2,$$

and

$$T = ace + 2bcd - ad^2 - eb^2 - c^3,$$

which latter is also the CATALECTICANT. These invariants, for the canonical form, reduce themselves to $1 + 3m^2$ and $m - m^3$ respectively. The coefficient m, therefore, is a root of the cubic

$$4m^3 - mS + T = 0.$$

Prof. Sylvester has shown (*Phil. Mag.* 1853) that every other invariant of a quartic can be expressed in terms of S and T; its discriminant, for instance, is $S^3 - 27T^2$. Having determined m from the foregoing cubic equation, the facients x and y of the canonical form are determined by considering the principal covariant of the quartic, which is its Hessian, H—another quartic easily obtained from the original. [HESSIAN.] For the canonical form the Hessian becomes

$$m(x^4 + y^4) + (1 - 3m^2)x^2y^2.$$

Hence the relation between the facients x, y, of the canonical form, and those of the original quartic U, may be deduced from the equations

$$x^4 + y^4 + 6mx^2y^2 = U,$$

$$m(x^4 + y^4) + (1 - 3m^2)x^2y^2 = H,$$

which latter gives readily

$$x^2y^2(1 - 9m^2) = H - mU,$$

and shows that

$$H - m_1U,\ H - m_2U,\ H - m_3U,$$

are each perfect squares, m_1, m_2, m_3, being the roots of the above cubic. But it may be shown further, that

$$(m_2 - m_3)\sqrt{H - m_1U} + (m_3 - m_1)\sqrt{H - m_2U} + (m_1 - m_2)\sqrt{H - m_3U}$$

is also a perfect square; and since it is manifestly reduced to zero by the hypothesis $U = 0$, its square root must be one of the four linear factors of U. This elegant solution of a biquadratic was first given by Prof. Cayley. The remaining important covariant of a quartic is the cubicovariant J of the first emanant; it is a sextic, which for the canonical form reduces to

$$(1 - 9m^2)xy(x^4 - y^4).$$

Further details on this subject will be found in Prof. Cayley's memoirs on Quantics in the *Phil. Trans.* 1855, and in Dr. Salmon's *Higher Algebra.*

Ternary Quartics equated to zero, represent *quartic curves* whose general properties have been but little investigated. Such curves might be classified according to the number of their double points or cusps, which can at most amount to three. [DOUBLE POINT.] The general curve, which has no such singularities, is of the 12th class, and the curve which has the

maximum number of cusps (three) is only of the 3rd class. Between these extremes may occur quartic curves of every other class. One interesting case is where the curve has a *triple point*, equivalent to three double points [MULTIPLE POINT]; its class is reduced to 6, 5, or 4, according as none, two, or all three of the tangents at the triple point coincide. The general quartic, of the 12th class, has 24 points of inflexion; the Hessian, which passes through them, being a curve of the 6th order. The 24 stationary tangents at these points of inflexion always touch a curve of the 4th class. The general quartic, too, has 28 double tangents, as was first shown, indirectly, by Plücker, and directly by Cayley. (Crelle's *Journal*, vol. xxxiv.) The equation of the curve of the 14th order which cuts the quartic in the 56 points of contact of its double tangents was given by Hesse (Crelle's *Journal*, vol. xli.) and Salmon (*Higher Plane Curves*). Through the four points of contact of any pair of double tangents, five conics can be drawn, each of which will pass through the four points of contact of another pair. In this manner 315 conics can be found, each of which will pass through the 8 points of contact of two pairs of double tangents. Salmon, in his *Higher Plane Curves*, has formed a scheme of them, and Steiner has also examined their relative positions and properties. (Crelle's *Journal*, vol. xlix.) The subject is, however, exceedingly complicated, and for further information the reader must be referred to the papers of Cayley, Hesse, Salmon, Jacobi, Steiner, &c., in the pages of Crelle's *Journal*, *Phil. Trans.*, and *Cambridge and Dublin Mathematical Journal*.

The best known quartic curves are the Cartesian and Cassinian ovals, the Limaçon of Pascal, the Cardioid, the Conchoid of Nicomedes, and the central pedals of Conics, which latter include the Lemniscata of Bernoulli. Short descriptions of these quartics will be found under their respective names.

With respect to *non-plane quartic* curves, or those which are cut by every plane in four, real or imaginary, points, the researches of Cayley, Salmon, Chasles, Steiner, and others, have made us familiar with many interesting properties. We can here merely notice their division into two families: *quadro-quadro quartics* and *ex-cubo quartics*, referring the reader for further information to the pages of Crelle's *Journal*, of the *Comptes Rendus*, and of Salmon's *Analytical Geometry of Three Dimensions*.

A *quadro-quadro quartic* constitutes the complete intersection of two quadric surfaces. Through such a curve, therefore, innumerable quadric surfaces can be drawn, amongst which will be four cones, and an infinity of hyperboloids of one sheet. No right line can meet such a curve in more than two points, so that the plane projection of the quartic can at most have double points (it will in general have two), and may possibly be a conic (doubled): in general, any plane cubic may be considered as the projection of a *quadro-quadro* quartic from a point on the curve. Further, such a quartic may always be regarded as the partial intersection of a cubic and a quadric surface which have in common a plane conic, and conversely two such surfaces always intersect in a *quadro-quadro* quartic curve.

There is, however, one interesting family of quartic curves, through which only one quadric surface, and that a ruled surface, can be drawn. These are called *ex-cubo quartics*. A quadric and a cubic surface which have in common two non-intersecting right lines, always intersect in such a curve. For every generator of the quadric which does not intersect the two common lines must necessarily meet the cubic, and therefore the quartic curve under consideration in *three* (real or imaginary) points. No second quadric, therefore, could be drawn through such a quartic curve; for not only it, but every other quartic which its existence implies, would have to cut all such generators in three points. An *ex-cubo* quartic meets one set of generators of the quadric surface on which it lies in three points, and those of the other set in one. Its projection on any plane, therefore, from a point on the curve, is always a cubic with a double point; its plane projection from any point in space is a quartic with three double points. Next to the non-plane cubic the *ex-cubo* quartic is the simplest of all curves of double curvature, and its points may be constructed linearly, as has been shown by Cremona (*Annali di Matematici*, t. iv. 1861).

Quartic surfaces have been but little investigated.

Quartile Aspect. In Astrology, this term denoted the aspect or appearance of two planets, whose positions are at a distance of 90° on the zodiac.

Quartine. The fourth envelope of the vegetable ovule, beginning to count from the outside.

Quartinvariant. [INVARIANT.]

Quarto. In Printing, a book printed in four leaves, or eight pages. It is abbreviated 4to.

Quartodecimans (Lat. quartus, and decimus, *tenth*). In Ecclesiastical History, a name applied to those who celebrated Easter on the fourteenth day of the paschal moon, instead of on the Sunday next following. This practice was maintained by the Eastern Christians, who appealed to the personal authority of St. John as a sanction for their observing the anniversary of the Jewish passover in the evening between the fourteenth and fifteenth of the month Nisan. But the Western with some of the Eastern Christians, on the ground that Christ was Himself the passover, broke their fast for the first time on the great festival of the resurrection on Easter Sunday. These appealed to the fourth gospel, which bears the name of St. John. In his great quarrel with the Roman bishop Victor, Polycrates, bishop of Ephesus (A.D. 190), grounded his retention of the Eastern usage on the un-

varying practice of Polycarp, Melito Philip, and St. John, while no direct reference is made to the fourth gospel, even by Apollinaris bishop of Hierapolis, a zealous opponent of the Eastern observance.

Quartz. A German term, now universally adopted in scientific language, and commonly applied to the purer varieties of silica, especially to Rock Crystal.

Quartzite or **Quartz Rock.** An aggregated rock consisting of quartz not absolutely crystalline. It sometimes appears in strata, and differs from sandstone in being more closely compacted and having a finer grain. It passes into sandstone on one hand and crystalline quartz on the other.

Quas. A fermented liquor used in Russia, and prepared from a mixture of meal and malt.

Quasi (Lat. *as it were*). In the language of Jurisprudence, this word, as a prefix, implies that the subject is something nearly related to, but not quite amounting to, that with which it is compared: thus, in Roman law, a *quasi-delict* and a *quasi-contract* are often spoken of; but it is essential to remember that as a *quasi-delict* is not a criminal offence, so a *quasi-contract* is no contract, express or implied, but only resembles one. 'The commonest sample is the relation subsisting between two persons, one of whom has paid money to the other through mistake.' Here, though morality raises a bond of duty in the receiver to return the money, there is no contract on his part to do so. (Maine's *Ancient Law*. ch. ix.)

Quasimodo. In the Roman Catholic Calendar, the first Sunday after Easter; so called because the *Introit* for that day begins with the words 'Quasi modo geniti infantes.' (1 Pet. ii. 1.) It is also called Dominica in albis, as being the day on which those who had been baptized on Easter Sunday deposited their white robes in the sacristy.

Quassia. The wood of the *Quassia amara*, a native of South America, and of *Picraena excelsa*, a tree found in some of the West Indian islands. It yields an intensely bitter infusion, which is used medicinally and is a good vehicle for metallic salts, many of which are decomposed by other bitter vegetable infusions. A strong infusion of quassia, sweetened with brown sugar, is an effective poison for flies.

Quassin. *Quassite*. The bitter colourless crystalline principle of quassia wood.

Quaternion (Lat. quaternio, *the number four*). Adopting, for conciseness, an expressive term employed by Sir William Rowan Hamilton, the inventor of the new science of Symbolical Geometry known as the *Calculus of Quaternions*, a quaternion may be defined as the *metrographic* relation which exists between any two right lines having definite lengths and directions in space. In what follows we purpose, solely, to convey a somewhat more accurate conception of a quaternion, and to explain briefly in what manner it depends, as its name implies, upon *four* irreducible geometrical elements.

The reader desirous of further information must be referred to Sir W. R. Hamilton's *Lectures on Quaternions*, Dublin 1853; to Dr. Salmon's *An. Geom. of Three Dimensions*; or to the recently published *Elements of Quaternions* by Sir W. R. Hamilton.

The operation of passing from any point O in space to any other point A is termed a *vector*, and denoted either by OA or a single symbol α, which must be regarded as involving the conceptions of length and direction, but not of position in space; so that two vectors OA and O′A′ will be equal if by simply moving the line OA parallel to itself, until O coincides with O′, its other extremity A falls upon A′. The addition of vectors is defined by the ordinary equations $OA + AC = OC$, which may be interpreted as indicating that the successive performance of the operations OA, OC is equivalent to the single operation OC. Thus the diagonal is the *geometrical sum* of the coinitial sides of a parallelogram or of a parallelopiped. The reverse operation to AB is denoted by $-AB$, and is clearly equivalent to BA, since by the above relation

$$AB + BA = AA = 0.$$

It is now clear that if i, j, k denote three fixed and mutually rectangular unit-vectors, any other vector ρ will be expressed by $ix + jy + kz$, where x, y, z are positive or negative numbers (*scalars*), expressing the ratios to unity of the ordinary coordinates of the extremity of a vector, equal to ρ, drawn from the coordinate origin. This being premised, we proceed next to the consideration of a *quaternion* or geometrical quotient $\frac{\beta}{\alpha}$, where β and α are any vectors. It is clear that OB and OA being any coinitial vectors equal to β and α, this quaternion may be represented by the *biradial* or unclosed triangle BOA; it may be also written thus $\frac{OB}{OA}$ and regarded as the operation necessary for changing OA into OB, so that

$$\left(\frac{OB}{OA}\right) OA = OB.$$

Now this operation may be resolved into, and perfectly defined by, two other *commutative* operations of *tension* and *version*; viz. *first* a stretching of OA until it attains the length of OB, and *secondly* a turning of the thus stretched line, from left to right, around a certain axis perpendicular to the plane of AOB, through the angle

$$\theta = A\hat{O}B \; (<\pi).$$

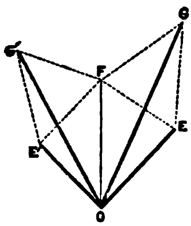
A quaternion is thus seen to be perfectly defined by four elements, viz. the ordinary *ratio* of OB to OA, the two angles which define the direction of the axis, and the angle θ.

To illustrate this still further, however, we remark that the representative biradial of a quaternion may have its sides lengthened or shortened as we please provided their ratio remains the same, may be transported into any parallel plane, and turned in any manner *in*

that plane. Again, if the multiplication of two coinitial quaternions be defined by the equation

$$\frac{OC}{OB}\cdot\frac{OB}{OA}=\frac{OC}{OA},$$

the products $\frac{\delta}{\gamma}\cdot\frac{\beta}{\alpha}$ and $\frac{\beta}{\alpha}\cdot\frac{\delta}{\gamma}$ of any two quaternions whatever may be thus exhibited.



Let the vectors α and β be parallel to the plane G′OEF, and γ and δ to GOE′F; and, having taken any point F in the intersection of these planes, let

$$\frac{OF}{OE}=\frac{OG'}{OF}=\frac{\beta}{\alpha},$$

and

$$\frac{OG}{OF}=\frac{OF}{OE'}=\frac{\delta}{\gamma},$$

then
$$\frac{\delta}{\gamma}\cdot\frac{\beta}{\alpha}=\frac{OG}{OF}\cdot\frac{OF}{OE}=\frac{OG}{OE}$$

and
$$\frac{\beta}{\alpha}\cdot\frac{\delta}{\gamma}=\frac{OG'}{OF}\cdot\frac{OF}{OE'}=\frac{OG'}{OE'}$$

These products, it will be seen, are not equal; for although the ordinary ratios OG : OE and OG′ : OE′ are equal, as well as the angles EOG and E′OG′, the planes of the respective biradials have not the same aspect. In the multiplication of quaternions, therefore, the order of the factors must be regarded. If the angles EOF = FOG′ and E′OF = FOG were all right angles, in other words if the factors $\frac{\beta}{\alpha}$, $\frac{\delta}{\gamma}$ were *rectangular quaternions*, then although the biradials EOG and E′OG′ would be in the same plane, the rotations would be of an opposite character; two such quaternions are termed *conjugate*. If the planes of the quaternions were also at right angles to each other, we should have

$$\frac{\beta}{\alpha}\cdot\frac{\delta}{\gamma}=-\frac{\delta}{\gamma}\cdot\frac{\beta}{\alpha}.$$

An ordinary *signless* number may clearly be represented by a quaternion, i.e. by the quotient of two like-directed vectors. Now since, by definition,

$$\frac{\gamma}{\alpha}=\frac{\gamma}{\beta}\cdot\frac{\beta}{\alpha},$$

we may, on supposing the perfectly arbitrary vector β to have the same length as α and the same direction as γ, or the same length as γ and the same direction as α, write

$$\frac{\gamma}{\alpha}=\mathrm{T}\left(\frac{\gamma}{\alpha}\right)\cdot\mathrm{U}\left(\frac{\gamma}{\alpha}\right)=\mathrm{U}\left(\frac{\gamma}{\alpha}\right)\cdot\mathrm{T}\left(\frac{\gamma}{\alpha}\right),$$

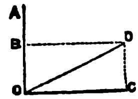
where the *tensor* T is represented by a pure number, and merely stretches, whilst the *versor* U turns without alteration of length. This illustrates the resolution of a quaternion into the product of its tensor and versor.

Another method of resolving a quaternion results from the following definition of the addition of quaternions:

$$\frac{OB}{OA}+\frac{OC}{OA}=\frac{OB+OC}{OA}=\frac{OD}{OA},$$

where OD is the diagonal of the parallelogram whose sides are OB and OC. As a particular case of the double application of this definition it will readily be seen that any rectangular quaternion whatever may be resolved into a sum of three rectangular quaternions in the fixed planes of the mutually rectangular vectors i, j, k.

Again, any quaternion $=\frac{OD}{OA}$ may by projecting OD upon the line of OA and upon a line perpendicular thereto, be expressed in the form



$$q=\mathrm{S}(q)+\mathrm{V}(q),$$

where the quaternion $\mathrm{S}(q)=\frac{OB}{OA}$ resolves itself into a *positive* or *negative number* or fraction, and is called the *scalar* of q, whilst the quaternion $\mathrm{V}(q)=\frac{OC}{OA}$ is rectangular and receives the name of the *vector* of q because, as will be presently apparent, a rectangular quaternion may always be represented by a vector, considered as an axis of right-handed rotation, whose length is equal to as many linear units as the tensor of the quaternion contains numerical ones.

In fact, if I, J, K, represent rectangular versors (quaternions with unit tensors) whose planes are respectively perpendicular to the fixed rectangular unit-vectors i, j, k, it will be readily seen that from the foregoing principles

$$\mathrm{IJ}=-\mathrm{JI}=\mathrm{K},\ \mathrm{JK}=-\mathrm{KJ}=\mathrm{I},\ \mathrm{KI}=-\mathrm{IK}=\mathrm{J},$$

each of which equations expresses the equivalence of certain operations. It is also evident, by operating upon the *subjects* i, j, k, that

$$\mathrm{I}j=-\mathrm{J}i=k,\ \mathrm{J}k=-\mathrm{K}j=i,\ \mathrm{K}i=-\mathrm{I}k=j.$$

These equations have precisely the same forms as the foregoing ones, so that the distinction between the rectangular versors I, J, K, and the corresponding unit-vectors i, j, k, need no longer be retained. When we please, therefore, the symbols i, j, k, may be regarded as operative ones which combine according to peculiar laws, all of which are expressed by the equations

$$i^2=j^2=k^2=ijk=-1.$$

Now, since every rectangular quaternion may be resolved into a sum of three rectangular quaternions in the coordinate planes, the quaternion $\mathrm{V}(q)$ above considered may be expressed in the form

$$xi+yj+zk,$$

where x, y, z, are positive or negative numbers; so that, denoting by w the positive or negative number $\mathrm{S}(q)$, we have the following irreducible expression for a quaternion

$$q=w+xi+yj+zk.$$

We cannot here enter into the applications of Quaternions to Geometry and Mechanics, and must close this very imperfect sketch of the elements of the calculus with the remark that, in it, $\sqrt{-1}$ is the general symbol of rotation through a right angle, and that the decomposition of a quaternion into its scalar and vector parts at once leads to an expression of the form

$$q = m\,(\cos\theta + \sqrt{-1}\,\sin\theta),$$

where m is a pure number, and θ the angle of the quaternion; whence it will be readily understood that a quaternion may be also represented as a *power of a vector*, considered as a rectangular versor. As in ordinary algebra, however, this symbol $\sqrt{-1}$ sometimes denotes, in the Calculus of Quaternions, an impossible operation. It then gives rise to what are termed *biquaternions*, for a definition of which, however, the reader must be referred to the writings of their eminent inventor.

Quatrain (Ital. quattrino). In Poetry, a piece consisting of four verses, the rhymes being usually alternate, but sometimes, especially in French poetry, intermixed, the first and fourth, second and third, rhyming together.

Quatrefoil (Lat. quatuor, *four*, and folium, *a leaf*). In Heraldry and in Mediæval Sculpture, a flower of four leaves (quatre feuilles).

Quattrocentismo (Ital. quattro cento). A term expressing the peculiar or characteristic taste or so-called *purism* in art, prevailing in Italy in the fifteenth century. Hard and rigid in its manner, positive in its colouring, but predominating in sentiment; yet æsthetically very imperfect, it is the triumph of the Cinquecento to have supplied the æsthetic qualities wanting in the art of this period, and to have reformed its technical deficiencies, the sensuous being made coordinate with the sentimental. [CINQUECENTO.]

Quaver. In Music, a character, ♪, whose measure is equal to half a crotchet, or one-eighth of a semibreve.

Quay (Fr. quai, Dutch kaai). An artificial landing place, to enable ships which could not otherwise approach the shore to take in or disembark their cargoes without the intervention of small boats.

Quay Wall. A wall forming the support of ground left at a higher level than that of the roadway, or waterway, of the surrounding surface; thus the walls of a platform or of a dock, or pier, are said to be the *quay walls*, irrespective of the nature of the element whose force they have to resist. The thickness of quay walls, however, depends greatly upon this condition, which will be found discussed under RETAINING WALL. It may suffice here to mention that in the case of walls intended to protect the earthwork left behind a quay wall erected in dry ground, a thickness equal to one-third of the height would, on the average, be sufficient; but that, in the case of earthwork exposed to alternations of moisture and dryness, as in docks or harbours, the thickness to be given to the quay walls should, on the average, be at least one-half the height.

Queen (A.-Sax. cwen, Gr. γυνή; for the history of the root, see LANGUAGE). 1. A female sovereign; entitled *queen regnant*, or *queen regent*. She has, in Great Britain, the same power, prerogatives, &c., as a king, which is expressly declared by stat. 1 Mar. I. st. 3. c. i. In France, where females do not succeed to the throne, the title *queen regent* has been given to the mothers of kings holding sovereign authority, or a portion of it, during the minority of their sons; as Catherine de Médicis in the reign of Francis II.; Mary de Médicis, in that of Louis XIII.

2. *Queen Consort*. The wife of a king. Her rights and dignities (in England, as well as most other countries) appear to be similar in many respects to those of the 'Augusta,' or Piissima regina conjux divi imperatoris, in imperial Rome. The English queen, like the Roman empress, is capable of receiving a grant from her husband, or making one to him; therein differing from all other wives. She can also purchase and convey land, &c., without his concurrence; and sue and be sued alone: in short, she is looked upon in all legal proceedings as a feme sole. But, except where she enjoys specific exemptions, she is only on a footing with other subjects; and this also is according to the Roman maxim, 'Augusta legibus soluta non est.' By the Statute of Treasons, 25 Edw. III., to compass or imagine the death of the king's *companion*, and also to violate and defile her, is treason. The queen, if accused of treason herself, is tried by the peers of parliament; as Anne Boleyn in 28 Hen. VIII. The consort of George IV. was proceeded against by the method of a bill of pains and penalties. *Queen-gold* was a duty amounting to one full tenth of the value of fines, &c. on grants by the crown, anciently due to the queen; which Charles I. purchased of his consort Henrietta, in 1635, for 10,000*l*., but which was not revived after the Restoration. The queen consort has a separate household, consisting of six ladies of the bed-chamber, a chamberlain, vice-chamberlain, mistress of the robes, master of the horse, and three equerries, attorney and solicitor general, &c.

3. *Queen Dowager*. The widow of a deceased king. She continues to enjoy most of the privileges which belonged to her as queen consort. Nor did she, in ancient times, lose her dignity on remarriage; for Catherine, queen dowager of Henry V., after she had married Owen Tudor, maintained an action by the name of Catherine queen of England. But it is held that no man can marry a queen dowager without special license from the king, on pain of forfeiture of lands and goods, according to an Act of 6 Hen. VI., which, however, is not printed among the statutes. The revenue of a queen dowager is settled by statute. By 1 & 2 Wm. IV. c. 11, that king was empowered to settle

100,000*l.* per annum on his queen, to commence at his decease.

4. *Queen Mother.* A queen dowager who is also mother of the reigning sovereign.

Queen Anne's Bounty. [BOUNTY, QUEEN ANNE'S.]

Queen Post. In Architecture, an upright post in a roof for suspending the beam when the principal rafters do not meet in the head of the king post. A queen-post roof is employed whenever the span of the assemblage is above forty feet; it makes, in fact, an arch of the timber. [ROOF.]

Queen's Advocate. [KING'S ADVOCATE.]

Queen's Bench. [KING'S BENCH.]

Queen's Counsel. It has been customary for a long period to appoint the leading members of the bar to be the standing counsel of the crown. This practice appears to have originated in the reign of Charles II., and has been gradually extended until the position of a queen's counsel has come to be regarded as a professional rank which any barrister of a certain eminence may claim almost as of right. The functions of queen's counsel as representing the crown by virtue of their office are now merely honorary, though they formerly received a small salary by way of retainer. They receive the usual fees if retained on behalf of the crown on any particular occasion. They cannot be employed in any cause against the crown without a special license, which is never refused, but which involves an expense of about 9*l.* on each occasion. As the crown is the nominal prosecutor in criminal proceedings, no queen's counsel can defend a prisoner without a license, a circumstance which has incidentally a considerable effect in preventing the leading members of the bar from practising in the criminal courts. Queen's counsel have a right of precedence and pre-audience over the other members of the bar (which constitutes the chief advantage of the appointment), and by the etiquette of the profession they are forbidden to conduct causes, or to prepare pleadings or other legal instruments without the assistance of a junior counsel. Their professional robes are of silk instead of stuff (whence the term *silk* is often used to denote their rank). They are usually elected to be benchers of their respective Inns of Court. [BENCHERS.]

Queen's Metal. An alloy intermediate between Britannia metal and pewter, used for the manufacture of common spoons and teapots. It consists of nine parts of tin, one of lead, one of antimony, and one of bismuth.

Queen's Regulations. The regulations and orders issued by the queen to the army (through the commander-in-chief, as distinguished from those issued through the Secretary of State for War, which are War Office regulations). They regulate the whole military system, except in matters affecting finance. They interpret the Mutiny Act and Articles of War as regards military discipline, and furnish the rules for the interior economy of the service. Every officer is required to possess a copy, and to make himself perfectly acquainted with them.

Quellerz. A German term signifying *brook iron-ore*, a synonym of Limonite or Bog Iron-ore.

Quercitannic Acid. The astringent principle of oak bark. It differs from the tannic acid of oak galls.

Quercite (Lat. quercus, *an oak*). A crystalline saccharine matter contained in acorns.

Quercitrin. *Quercitric acid.* The colouring matter of quercitron bark. It is a crystalline, yellow, bitter substance.

Quercitron Bark or **Quercitron Tinctoria.** The bark of the *Quercus nigra.* This valuable dye stuff is used in the production of some of the most durable yellows. It contains a yellow crystallisable principle, *Quercitrin*, which is sparingly soluble in water, but is readily solved in weak alkalies. A decoction of this bark, deprived of its tannic acid by a little gelatine, produces a good yellow upon fabrics mordanted with alumina, or various shades of olive, with iron mordants. It is much used in calico-printing.

Quercus (Lat.). This is the most important genus of trees found in the cold countries of the world, on account of its producing the various kinds of timber called OAK. The species are not, however, confined to Europe, or similar latitudes, but occur abundantly in the equinoctial parts of Asia and America. It is usually recognised by the cup in which the acorn is seated; but in some tropical species the acorn is so small as to be buried in the cup, when the fruit nearly resembles that of the chestnut (*Castanea*). The valuable Oak of Great Britain is obtained from two native trees: the one *Q. pedunculata*, the long-stalked or white oak; the other *Q. sessiliflora*, the sessile-fruited or red oak. Oak timber is affected very much by soil and climate; and hence we have oak of bad quality from both our native species. What is called wainscot oak is probably the timber of *Q. sessiliflora*, grown rapidly in the dense forests of Hungary; by some persons, however, it is supposed to be furnished by an Oriental species called *Q. Cerris*, or the mossy-cupped. The *Æsculus* of Virgil, the acorns of which were eatable, appears to have been a sweet-fruited variety of *Q. sessiliflora.* Besides those already mentioned, the *Quercus Ilex*, or European oak, the *Q. Suber*, or cork-tree, whose bark is in such extensive use, and the *Q. Ballota*, or Spanish Ilex, whose acorns are sweet and eatable, are the more important species. Those from North America, although fine trees, are inferior to the oaks of England as regards their timber, and require hotter summers than we have in these islands. Oak galls are produced upon *Q. infectoria*, in the Levant, by the puncture of a cynips. The species of *Quercus* are excessively confused by botanists; but a full popular account of them will be found in Loudon's *Arboretum Britannicum*, and a scientific summary in the sixteenth volume of De Candolle's *Prodromus.* For a few popular details, see OAK.

Question (Lat. quæstio). The application of TORTURE to prisoners under criminal accusation, according to the law of France before the Revolution. The question was of two kinds: one, where strong evidence, but insufficient of itself to justify a condemnation to death, existed against a prisoner on a capital charge; he might then be subjected to torture to produce confession. This was termed the *question préparatoire*. It was abolished by an ordonnance of Louis XVI. in 1780. The other, termed *question préalable or définitive*, was applied to the prisoner when convicted of a capital offence, in order to make him discover supposed accomplices. It was abolished by the National Assembly. The preparatory question was also of two sorts: one, *avec réserve de preuves*, in which case, if the criminal did not confess under the torture, the other evidence was considered as still subsisting against him, so as to justify his condemnation to some lighter punishment; the other, *sans réserve de preuves*, in which case, if he persisted in his denial, he was acquitted altogether. It was at the option of the judges, according to their opinion of the amount of evidence, to decide to which of these questions the accused should be subjected. The modes of torture applied varied in France, being fixed by the several parliaments within their separate jurisdictions. (See a very curious dissertation on this horrible subject by M. Berriat Saint-Prix, *Des Tribunaux et de la Procédure du Grand Criminel au* 18° *Siècle*, 1859.) Those in common use at Paris were, the question by water, which consisted in stretching the limbs of the sufferer on a board by means of screws, and forcing him to swallow large quantities of water; and the boots, in which his legs were enclosed in wooden cases, the whole tightly compressed with ropes, and wedges driven with a mallet between the two cases. The question varied in degree, being *ordinary* or *extraordinary*, at the discretion of the judges. Children and adolescents, old men, and women with child, were excepted from torture by the French law. And, by an ordonnance of 1670, the second application of the question was forbidden in all cases. [RACK; TORTURE.]

Question, Previous. [PREVIOUS QUESTION.]

Questmen (Lat. quæstus, *a seeking*). Parochial officers sometimes appointed in large parishes to assist the churchwardens in enquiring into abuses, making presentments, &c.

Qui pro Quo or **Quid pro Quo** (Lat.). A conventional term borrowed from the French, who apply it to an error committed by mistaking one thing or person for another. In England it is used also in the sense of an equivalent.

Qui Tam (Lat. *who as well*). In Law, a penal action, in which half the penalty is given to the crown and the rest to the informer. The plaintiff, while Latin forms were in use, described himself as A. B. 'qui tam pro domino rege quam pro se ipso'—who sues as well for the king as himself.

Quia Emptores (Lat.). In English Law, the designation (from its first words) of the statute 18 Edward I. (A. D. 1290) which prevented subinfeudation. [FEUDAL SYSTEM.]

Quick Match. [MATCH.]

Quicklime. [LIME.]

Quicksilver. [MERCURY.]

Quietism. A name generally applied to the opinions of enthusiasts, who conceive the great object of religion to be the absorption of all human sentiments and passions into devout contemplation and love of God. This idea has found its admirers in all ages. A sect called by this name [HESYCHASTS] existed among the religious of Mount Athos; and in the seventeenth century it was given in France to a class of devout persons with a tendency towards a higher spiritual devotion. A Spanish priest, Molinos, published at Rome a work entitled *The Spiritual Guide* (1675), of which the ardent language attracted a multitude of partisans. Its leading feature was the description of the happiness of a soul reposing in perfect *quiet* on God, so as to become conscious of His presence only, and untroubled by external things. He even advanced so far as to maintain that the soul in its highest state is removed even beyond the contemplation of God himself, and is solely occupied in the passive reception of divine influences. The work of Molinos was afterwards condemned on the application of the Jesuits. Akin to the ideas of Molinos seem to have been those of the French Quietists, of whom Madame Guyon and Archbishop Fénelon are the most celebrated. The former was at one time treated as insane; at another, she was admitted to the intimacy of Madame de Maintenon, and rose high in court favour. Fénelon praised her in his treatise *Sur la Vie Intérieure* (1691). The writings of the latter upon this subject were finally condemned by Innocent XII.; and the example of the archbishop in submitting to the decision has been dwelt on by pious writers as a signal triumph of a religious mind. The dissolute conduct of some hypocritical priests, under the pretence of inculcating the tenets and practice of Quietism, brought it eventually into disrepute more than the repeated condemnations of the head of the Roman Catholic church.

Quilted Armour. Armour formed of soft material padded, and stitched at regular intervals, so as to keep the padding in its place. This armour is also called *pourpointed*, and was much worn in the middle ages.

Quincite. A hydrated silicate of magnesia and protoxide of iron, of a carmine-red colour, found disseminated in a fresh-water limestone, near Quincey, in the Département du Cher.

Quincunx. The Latin term properly for that disposition of five objects in which they are made to occupy the four corners and point of intersection of the diagonals of a square; but the word is extended to any number of things so arranged in lines that the members of each succeeding line stand behind the spaces between those of the preceding one. Troops

were frequently drawn up in this order, which was also a favourite arrangement for plantations of vines.

Quindecagon. In Geometry, a plane figure bounded by fifteen sides. The regular quindecagon is inscribable in a circle by elementary geometry. (*Euclid*, book iv.)

Quindecemviri. Roman magistrates, whose duty it was to take care of and to consult the Sibylline books.

Quinia or **Quinine.** An alkaline base obtained chiefly from yellow bark, *Cinchona Calisaya*, and other species. This substance, combined with sulphuric acid, forms the *sulphate of quinine*, now extensively used as a medicine, and as a substitute for the various forms of Peruvian bark. To obtain quinine, bruised yellow bark is boiled in repeated portions of water, acidulated by sulphuric acid, till all its soluble matters are extracted; a little excess of quicklime is then added to the strained decoction, and the precipitate which is formed is collected, washed, and carefully dried; it is then digested in alcohol, which takes up the quinine, and from which the latter may be obtained in the form of a yellowish substance by careful evaporation. It is dissolved in dilute sulphuric acid, and the sulphate of quinine crystallises from its concentrated solution in fine silky prisms, which effloresce on exposure to air. Sulphate of quinine is not easily soluble in water, and is intensely bitter. It is administered as a tonic and febrifuge in doses of from one to five or six grains.

The composition of quinine, in its anhydrous state, is represented by the formula $C_{40}H_{24}O_4N_2$, and the crystallised sulphate, as sold for medical use, is a compound of one atom of sulphuric acid, one of quinine, and fourteen of water. Its high price renders it liable to various adulterations. Quinine appears to be associated in the barks which afford it with some other analogous alkaloid, and the mixture is called *quinoidine*, and is said to contain two bases isomeric with quinine which have been termed *quinidine* and *quinicine*.

Quinicine. An alkaloid much resembling quinine and quinidine, from either of which it may be prepared by applying a temperature below their fusing point for a few hours.

Quinidine. One of the cinchona alkaloids. It is an isomer of quinine, which it much resembles; but it more readily crystallises, a much larger quantity of it is required to be taken into the system before an effect is produced equal to that obtained by a given amount of quinine, and finally its solutions have an opposite action on a ray of polarised light. Under the names of *quinidine* and *quinoidine*, various substances are sometimes sold for medical use, as comparatively cheap substitutes for sulphate of quinine, but on account of their indefinite composition they cannot be relied on.

Quinoidine. [QUINIDINE.]

Quinquagesima Sunday. In the Calendar, the seventh Sunday before Easter, and consequently *about* the fiftieth day before that festival; whence the origin of the term, from Lat. quinquagesimus, *fiftieth*.

Quinquatrus. In Roman Antiquities, the feast of Minerva, which began on March 19, and lasted five days.

Quinquennalia or **Ludi Quinquennales.** In Classical Antiquity, public games celebrated every five years. Tacitus (*Ann.* xiv. 20) says that they were introduced at Rome by Nero.

Quinquereme (Lat. quinqueremis, Gr. πεντήρης). The name of a class of Roman war ships rowed by five banks of oars. The introduction both of quadriremes and quinqueremes is attributed to the Syracusan tyrant Dionysius the Elder; while the younger Dionysius is said to have possessed hexeres, or ships with six sets of rowers. Polybius says that the first Punic war was carried on chiefly with quinqueremes. At Athens vessels larger than triremes were not introduced till about the time of Alexander the Great; and we first hear of a quinquereme in a document of B.C. 325. It is a matter of dispute how the banks of oars were disposed: some maintaining that they were above each other, others that such an arrangement must involve an impossible length of oar for the upper bank. Yet in works of art the ranks of oars appear one above another, although not perpendicularly; and thus more room was furnished for the various classes of rowers. In the ships ranging from the moneris (or ship with one bank of oars on each side) up to the quinquereme, each oar is said to have been managed by one man; but it is obviously impossible that one man could manage the long oars of a τεσσαρακοντήρης, thirty-eight cubits in length. For further details see Smith's *Dictionary of Greek and Roman Antiquities*, art 'Navis.' [TRIREME; GALLEY.]

Quinquina. Peruvian bark. The bark of various species of CINCHONA.

Quinsey (Ital. squinanzia, Gr. κυνάγχη). Inflammation of the tonsils. This is common inflammatory sore-throat: it is not infectious. It begins with pain on one side of the throat, and swelling of the tonsil, or of both tonsils at the same time, attended by febrile symptoms, which sometimes run high, especially as the tumefaction advances; there is great restlessness and anxiety, and often the utmost difficulty of swallowing even liquids, and of breathing. The disease has proved fatal by producing suffocation, but it generally terminates in resolution or suppuration: in the latter case the abscess breaks, a good deal of pus is discharged, and the patient is at once relieved of all his urgent symptoms.

Quintain (Fr. quintaine). An ancient pastime, in which a post was erected, with a crosspiece, turning upon a pivot on the top of it, to one end of which a sand-bag was suspended, and a board fixed at the other. The play consisted in riding or tilting against the board with a lance, and passing without being struck behind by the sand-bag.

Quintal. An old denomination of weight, being the same with the *hundred* weight, or equal to 112 pounds.

Quintessence (Lat. quinta essentia). A term applied by the older chemists to alcoholic tinctures or essences, made by digestion at common temperatures or in the sun's heat. In Alchemy it denoted the fifth or highest essence of power in a natural body.

Quintic. In the Higher Algebra, this term denotes a homogeneous function of the fifth order in the variables. [QUANTIC.] The theory of binary quintics has been most studied on account of its connection with algebraical equations of the fifth degree, the most general form of which is

$$x^5 + ax^4 + bx^3 + cx^2 + dx + e = 0.$$

Various attempts have been made by mathematicians to effect a finite algebraic solution of the quintic equation, i.e. to express a root of it by means of finite combinations of radicals and rational functions, as can be done for quadratic, cubic, and biquadratic equations. In particular cases such solutions have been discovered. Thus, De Moivre found that when the quintic takes the form

$$x^5 - 5bx^3 + 5b^2x - 2e = 0,$$

one of its roots is

$$\sqrt[5]{e + \sqrt{e^2 - b^5}} + \sqrt[5]{e - \sqrt{e^2 - b^5}};$$

and Euler found that when the quintic takes the form

$$x^5 + 5cx^3 + 5dx - \left(\frac{c^5}{d} - \frac{d^5}{c}\right) = 0,$$

one of its roots is

$$\sqrt[5]{\frac{c^3}{d}} - \sqrt[5]{\frac{d^3}{c}}.$$

These and other cases have been shown by Harley to be included in a large class of solvable forms. (*Manchester Memoirs*, vol. xv. second series, pp. 172–219.)

But all the attempts of mathematicians to discover a finite algebraical solution of the general quintic have hitherto failed. Abel, indeed (*Œuvres complètes*, Christiana 1839), has demonstrated that it is impossible, except in particular cases, to effect a finite algebraic solution of any equation of a higher degree than the fourth. His argument has been reproduced and modified by Sir W. R. Hamilton. (*Trans. Royal Irish Acad.* vol. xviii.; Abstract of Hamilton's Exposition by Cockle, *Quart. Journ. of Math.* vol. v.) A shorter and more simple demonstration of Abel's theorem has been given by Wantzel, and reproduced in Serret's excellent *Cours d'Algèbre Supérieure.*

Another important discovery which has been recently made in the theory of quintic equations is that the general quintic equation can be deprived of any three of its four middle terms by the aid of equations of inferior degrees, and so reduced to one of the following four trinomial forms:

$$x^5 + dx + e = 0$$
$$x^5 + cx^2 + e = 0$$
$$x^5 + ax^4 + e = 0$$
$$x^5 + bx^3 + e = 0.$$

In any one of these four forms we may make either the last coefficient e; or the intermediate coefficient a or b or c or d equal to unity or to any other assumed number except zero; so that the general quintic equation may, by the aid of lower equations, be reduced to a trinomial form involving only a *single variable parameter.* (See Jerrard's *Essay on the Resolution of Equations*, London 1859; also an historical paper by Harley in the *Quart. Journ. of Math.* vol. vi. 1863.)

Availing himself of this reduction of the general quintic to a trinomial form, involving only one parameter, M. Hermite, in his *Essai sur la Théorie des Equations modulaires et la Résolution de l'Equation du Cinquième Degré* (Paris 1859), has succeeded in expressing the roots of the quintic in terms of elliptic functions, and M. Kronecker, in Crelle's *Journal*, has shown that the same thing can be done for the equation in its complete form.

Attacking the problem from a different point, Harley, in vol. v. of the *Quart. Journ. of Math.*, has calculated a certain linear differential equation of the fourth order and remarkably simple in form, whose solution is shown to embrace the solution of the general quintic equation. [DIFFERENTIAL RESOLVENT.]

Quintile. In Astronomy, an aspect of two planets distant from each other the fifth of the zodiac, or 72°.

Quintine (Lat. quintus). In Botany, a name given to the fifth or innermost envelope of the vegetable ovule, the most external being the first or primine.

Quintuple. In Music, a species of time, now seldom used, containing five crotchets in a bar.

Quinzaine. In Chronology, the fourteenth day after a feast day, or the fifteenth if the day of the feast be included. But a different rule seems to have prevailed on the Continent. (Sir H. Nicolas, *Chronology of History*, p. 105.)

Quire. In Printing, a bundle of paper consisting of twenty-four sheets. A quire of newspapers consists of twenty-five sheets.

Quirinus. According to Dionysius of Halicarnassus, this is a Sabine word, derived, perhaps, from quiris or curis, *a spear*, with which some have connected the word curia, *a senate house.* Under this name ROMULUS was worshipped by the Romans after his deification.

Quirites. In Roman Antiquities, this name occurs in the expression *Populus Romanus Quirites.* By some it has been supposed that this phrase refers to a coalition of two tribes, the Romans and the Quirites, the latter belonging, perhaps, to a town called Cures or Quirium. But in the absence of all historical evidence, these suppositions can neither be proved nor refuted. According to Bekker, the name Roman denoted the people in its rela-

tion to foreign nations, while by Quirites were signified the citizens as individuals and in their social relations. Thus a man who claimed anything as exclusively his own, was said to claim it *ex jure Quiritium*.

Quirk. In Architecture, a piece of ground cut off from a square plot.

Quirked Moulding. In Architecture, a moulding in which the convexity is sudden, being in the form of a conic section.

Quit Rent (Lat. quietus reditus). In Law, a small rent payable by tenants of manors, so called because thereby the tenant is quit and free of other services. [Rent.]

Quiver (perhaps another form of the word *cover*). The receptacle for arrows of the long-bow, worn by the archer.

Quo Warranto. In Law, a writ, filed in the Court of Queen's Bench by the Attorney-General, or an individual in his name, calling upon the person informed against to show by what title he holds any office, franchise, or liberty. As the proceedings on a writ of quo warranto presented many difficulties, the writ has been superseded in modern times by what is termed an information in the nature of a quo warranto. [Corporations, Municipal.]

Quodlibet (Lat. *what you please*). In the language of the schoolmen, questions on general subjects within the range of their enquiries were termed *questiones quodlibeticæ*, or miscellaneous. What is termed in Music a *pot-pourri* was also called in Germany a *quodlibet*.

Quoin (Fr. coin, Gr. γωνία). In Architecture, the corner, or the internal and external angle of a building, or of any part of a building. It is generally applied to the stones that form the angles. These are spoken of as the quoin stones, to distinguish them from the rest of the ashlar.

Quoin. In Artillery, a wedge of wood put below the breech of a cannon, for the purpose of adjusting its elevation.

Quoin. On Shipboard, a wedge used in stowing casks, to prevent motion.

Quorum. A term derived from the words used in the Latin form of the commission issued to justices of the peace; in which the expression occurred, 'quorum unum A B esse volumus'—'of whom we will that A B be one;' thus rendering it necessary that certain individuals (said to be of the quorum) should be present at the transaction of business. Hence, when in an assembly, committees, &c. it is necessary that a certain number should be present to give validity to its acts, that number is generally said to constitute a quorum.

Quota (Lat. quotus, *of what number*). That part which each member of a society has to contribute or receive in making up or dividing a certain sum.

Quotation Marks. In Printing, two inverted commas placed at the beginning, and two commas in their direct position (or two apostrophes), at the end of a sentence quoted or transcribed from an author in his own words. They are called *guillemets*, from their inventor Guillemet, and by the Germans *gänse-augen*, or geese-eyes.

Quotidian (Lat. quotidianus). That form of ague which returns daily. [Ague.]

Quotient (Lat. quotiens, *how often*). In Arithmetic, the result of the operation of division; it may be either a concrete or an abstract number. When a magnitude of any kind is proposed to be divided into any number of parts, and the divisor is consequently an abstract number, the quotient is of the same kind with the dividend or quantity proposed to be divided; but when the dividend and divisor are both things of the same denomination, or both magnitudes of any kind, the quotient is an abstract number, and is the ratio of the one magnitude to the other.

R

R. One of the letters belonging to the series called *liquids* or *semivowels*. At the beginning of English words derived from the Greek through the medium of the Latin, *r* is usually followed by *h*, to represent the force of ῥ, as in *rhetoric*, *rhapsody*, as also when it occurs in the middle of an English word derived from a Greek compound, as in *diarrhœa*, from διά and ῥέω. This letter is susceptible of numerous interchanges, more especially in Latin. As an abbreviation, R. among ourselves stands for *rex* or *regina*; R. P. for *respublica*, &c. In medical prescriptions, R. stands for *recipe* or *take*.

Rabbet of the Keel (Fr. raboter, *to plane*). In Wooden Shipbuilding, an angular groove running on each side of the keel from end to end, and serving to receive the inner edge of the garboard strakes or lowest planks of the ship's bottom. In merchant vessels the rabbet is usually formed along the top edge of the keel. In the British Navy, on the other hand, its position is nearly half-way down the keel, the keel itself being mortised into the floors down to the top of the rabbet. This latter formation is considered to impart much greater strength, as it admits of thicker strakes, and from the less depth of keel left exposed below the rabbet diminishes the disruptive force brought to bear on the vessel's bottom in the event of her taking the ground. Similar rabbets on the stem and sternpost receive the ends of the several planks of the sides.

Rabbi. A Hebrew term for *doctor* or *teacher*; the termination being properly the first pronoun possessive. This word, which is frequently found in the New Testament, is in use at the present day, the rabbis being the expounders of the law, and more particularly of the TALMUD or commentaries of later doctors.

Rabbinism. A term under which is commonly designated the body of doctrine of the *rabbis* or Jewish teachers subsequent to the Mosaic law, and which had its commencement about the time of the dispersion. It is considered to have derived its origin from the teaching of the Pharisees, mingled with Greek and other foreign elements. The followers of Hillel and Schammai, who flourished respectively about the commencement of the Christian era, formed the two leading schools of Rabbinism. [TALMUD; TARGUM.] The most brilliant period of Rabbinism was in the twelfth century under the teaching of Aben Ezra and Maimonides in Spain. The latter is the compiler of the thirteen articles which may be termed the modern creed of Judaism; establishing the unity and spiritual nature of God; the inspiration of Moses and the Prophets; the immutability of the Mosaic law; future rewards and punishments; and the expectation of the Messiah. Since that period, Rabbinism has either degenerated into mere formalism and puerilities, or expanded into a kind of philosophical Deism.

Rabbit. The *Lepus cuniculus* of Linnæus, a well-known domesticated rodent, which in its wild state is distributed over the whole of the northern hemisphere.

Rabdomancy. [RHABDOMANCY.]

Raca. An ancient Syriac word, signifying vanity or folly, and pronounced by the Jews with certain gestures of indignation. (Matt. v. 22.)

Race (Fr.). In Anthropology. [MAN; TEUTONIC.]

RACE. In Language. By philologists, nations or tribes which are found speaking the same language, or closely allied dialects, are said to belong to the same race. The expression conveys a certain amount of truth, but it must be used with great caution and within strictly defined limits. When it is said that the English soldier struggling with the Hindu sepoy during the mutiny of 1857 did not know that his enemy was his kinsman, this must be taken to mean that he was ignorant of the affinity of their several dialects, and of all that is implied in this affinity. This agreement, whatever be its measure, certainly proves that the ancestors of the Englishman and of the Hindu either belong to the same stock, or have at some time or other been thrown together; it shows further that from the same source they derive to some extent not only their civilisation, but their modes of thought. It is almost certain that they must in some measure share a common blood; but to what extent they may be anthropologically connected, it may be either difficult or impossible to ascertain. In Great Britain, English, Gaelic, and Welsh are spoken in different parts of the country. This fact proves that Teutonic and Celtic tribes have been brought together; and if, as in England, the Teutonic dialects predominate, this shows that at some time or other some tribes belonging to the Teutonic race were dominant in this country; but it does not hence follow that the great body of the English people are Teutonic, although a certain proportion of them must be. In other words, the population of this country is a mixed race; and although there is no such thing as a mixed language [LANGUAGE], an ethnological race is rarely, if ever, found altogether unmixed. Invasion, conquest, emigration, colonisation have constantly interfered with their purity. Hence the attempt to classify ethnological races or tribes by their languages can lead only to error. The fair Tahitian would thus be proved to be closely akin to the black natives of the Fiji islands. In Professor Max Müller's words, 'The science of language and the science of ethnology have suffered most seriously from being mixed up together. The classification of races and languages should be quite independent of each other. Races may change their languages, and history supplies us with several instances where one race adopted the language of another. Different languages may be, therefore, spoken by one race, or the same language may be spoken by different races; so that any attempt at squaring the classification of races and tongues must necessarily fail.' (*Lect. on Language*, first series.)

Raceme (Lat. racemus, *a bunch of grapes*). In Botany, a form of inflorescence, in which the flowers are stalked along a common unbranched axis, as in the Hyacinth and the Currant.

Racemic Acid (Lat. racemus). An acid found, together with the tartaric acid, in the tartar obtained from certain vineyards on the Rhine. It is the *paratartaric acid* of Berzelius. It is less soluble in water than tartaric acid, and differs in the form of its crystals and in its salts. It is *isomeric*, and has the same equivalent with tartaric acid. [TARTARIC ACID.]

Races. A name denoting particular spots in the sea where the water is disturbed by the meeting of two rapid currents, and not, as is supposed by sailors, by rocks projecting from the bottom of the sea. By the inhabitants of the Orkney islands, these races are called *roosts*.

Rachilla (Gr. ῥάχις, *a spine*). In Botany, a branch of inflorescence; the zigzag centre, upon which the florets are arranged in the spikelets of grasses.

Rachis (Gr. ῥάχις). In Botany, a branch which proceeds in nearly a straight line from the base to the apex of the inflorescence of a plant. The term is also applied to the main axes of the leaves of ferns.

RACHIS. A term applied by Illiger and other zoologists to the vertebral column of mammals and birds.

Rachitis (Gr. ῥαχῖτις, from ῥάχις, *the spine*, the part principally affected). The rickets. A disease generally confined to childhood, known by a large head, protruded breast-bone, flattened ribs, tumid belly, emaciated limbs, and great general debility; the bones in general, and especially the spine, are variously distorted and deficient in bony matter. The system occasionally rallies from this state as growth advances, but more or less deformity remains. Tonics, cold bathing, regular and proper exercise, very careful nursing, and occasionally rhubarb and tonic aperients, are the principal remedies; and where particular bones are inclined to bend, attempts must be made to throw the weight off them. This disease is frequently symptomatic of a scrofulous state of the glands and viscera; the stomach and bowels are always greatly deranged; and as there appears to be a deficiency of the hardening matter of the bones, various salts of lime, and even phosphate of lime, have been prescribed; the only apparent use of these last-named remedies is to render the gastric juice less acrid and acid.

Rack (A.-Sax. racan). An instrument of torture formerly used in England. According to Coke (who, however, merely reports the story on traditional authority), the rack was first introduced into the Tower by the duke of Exeter, constable of the Tower in 1447; and thence called *the duke of Exeter's daughter*. (3 *Inst.* p. 34.) Stowe, in his *Chronicle*, says that the duke's daughter herself invented it. The earliest mention of the use of the 'rack or brake' is by Holinshed, under the year 1467. But it first became common in the reign of Henry VIII. Under that prince, the remaining Tudors, James I. and Charles I., down to 1640, the rack was a common implement of torture for prisoners confined in the Tower, and inflicted by a warrant of the council or under the sign manual. The rack consisted of an oblong frame of wood, composed of four beams a little raised above the ground; the sufferer was fastened by the hands and feet to the corners, where two cross beams joined the longer ones, sometimes by small cords attached to each finger and toe; and the cords were twisted by means of rollers, so as to raise him from the ground, and stretch his body with extreme violence, dislocating the limbs, and, according to the Jesuit writers, who have left the most vivid representations of the sufferings of their companions under the state persecution of Elizabeth, sometimes extending the sufferer 'more than a palm beyond his usual stature!' (Jenner, *Societas Europæa*, p. 12; Jardine's *Reading on the Use of Torture in England*, 1837.) The Roman *equuleus* is often translated *rack* by English writers; but whether the equuleus was something similar to the English engine, or a wooden *horse* (as the derivation of the word implies), or, in short, what was its form and description, antiquaries have not been able to discover. (See, among other authorities, the learned treatise of Magius *De Equuleo.*) [QUESTION; TORTURE.]

RACK. In Machinery, a rectilinear sliding piece, having teeth cut on its edge so that they may work with those of a wheel or pinion which drives or follows the rack. The rack may be regarded as a toothed wheel whose radius is infinite.

Rack Rent. [RENT.]

Racovians. In Ecclesiastical History, the Unitarians of Poland are sometimes so called; from Racow, a small city of that country, where Jacobus à Sienna, its head, erected a public seminary for their church in 1600. Here the *Racovian Catechism*, originally composed by Socinus, and revised by his most eminent followers, was published. (Mosheim, *Eccl. Hist.* cent. 16, sec. 3.)

Radiant Heat. When a hot body is freely suspended in air, it cools down to the temperature of surrounding objects; when suspended in a space void of air, it still cools down. The chilling, in part in the former case, entirely in the latter, is caused by a process termed *radiation*: the investigation of the phenomena which attend the emission, transference, and stoppage of these rays forms the science of radiant heat. For a long time it was thought that this cooling took place by the hot body darting out from its substance particles of what was termed the matter of heat or caloric, the presence of which constituted warmth. These particles impinging on our sensory nerves caused the sensation of warmth, in the same way as the matter of light emitted from a luminous source falling on the retina was supposed to produce the impression of light. [LIGHT.]

This theory, so long held as regards the propagation both of heat and of light, has now given way to another which completely satisfies experimental and mathematical enquiry. This is the undulatory theory, already explained under the article LIGHT. Precisely the same reasoning there employed can be applied to the passage of heat through space.

The warmth of a hot body is supposed to be due to a state of rapid vibration amongst the particles of the substance, just as the sound of a bell is caused by the motion of its mass. When a bell suspended by strings is set in motion within an exhausted receiver, its ringing cannot be heard until the air is admitted. By means of the intervening air the vibrations of the sounding bell are taken up and communicated in pulses to the ear. By a similar but hypothetical medium called the ether, the vibrations of a hot body are transmitted in a series of waves to the sensory nerves. Radiant heat thus defined consists of this undulatory motion of the ether, a motion which travels through space with the velocity of light; and, as it does not in the slightest degree raise the temperature of the medium by which it is propagated, it passes through space without loss.

Since the early edition of this work appeared, the science of radiant heat has grown to such an extent that the few lines which were sufficient to describe its phenomena in 1840 could now

be replaced by a voluminous work. Owing to this, it will be necessary, in order to give a clear and succinct view of its varied phenomena, to class them under different heads.

Apparatus.—The apparatus now employed for investigations on radiant heat was first introduced by an Italian philosopher named Melloni, and is of the most perfect character. It consists of an instrument called a *thermo-electric pile*, by which small changes in temperature are rendered sensible by the production of an electric current, the strength of which is measured by its power of deflecting the needle of a sensitive galvanometer. [THERMO-ELECTRICITY.] It has been found by experiment that rock salt has the property of transmitting radiant heat with scarcely any diminution of the rays; hence this substance, as well as the thermo-pile, are indispensable in researches on radiation.

Fundamental Laws of Radiant Heat.—1. Radiation takes place and is transmitted through a vacuum as well as in air. This was proved by Count Rumford and Sir H. Davy at the beginning of this century. 2. Heat is emitted in a right line from every point on the surface of a hot body, spreading therefore in all directions round such a body. 3. Its intensity in a vacuum varies inversely as the square of the distance from the radiating point. 4. The amount of radiation, or the rate at which a body parts with its heat, is proportional to the excess of the temperature of the body above that of the medium in which it is placed. This law, though assumed by Newton, is found by experiment to hold good only within a certain range of temperature, not exceeding 50° of Fahrenheit. At higher temperatures Dulong and Petit found the rate of cooling to be more rapid than in the ratio stated. 5. All bodies placed in an enclosed space assume in time the temperature of the enclosure. 6. The intensity of the heating ray is as the sine of the angle which it makes with the surface. This law, however, is not general. 7. The nature of the source, as will subsequently be seen, greatly modifies both the intensity and quality of the radiation.

The only satisfactory hypothesis of the radiation of heat was that enunciated by Prevost of Geneva, about the year 1790, and known under the name of the *theory of exchanges*. Its leading principle is that all bodies are perpetually exchanging their heat with one another. It follows, therefore, that radiation takes place with greater or less intensity at all temperatures; that it is reciprocal between distant bodies; and that it subsists when the temperatures are equal, though in this case no alteration of temperature takes place, for each body then receives as much as it emits: this state is called the mobile equilibrium of temperature. This theory readily explains the apparent radiation of cold, such as is experienced when a block of ice is held near the face. In this case, although an interchange of heat still takes place, the human face, being the warmer body, emits more rays than it receives from the ice; hence its temperature sinks, and we feel chilled.

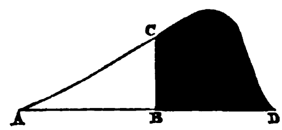
Phenomena analogous to Light.—We have already seen that the *intensity* of radiant heat, like that of light, diminishes as the square of the distance from the source. The *reflection* of radiant heat must have been a matter of common experience from the earliest times. The first systematic experiments which established this property were made by De Saussure and Pictet, by means of concave metallic mirrors. While engaged in these experiments, they found that radiant heat passed through a space of 69 feet in an inappreciable time. With more delicate apparatus Melloni subsequently established the strict analogy between the reflection of light and radiant heat, showing that the incident and reflected rays form the same angle with a perpendicular to the reflecting surface, and that reflection takes place in the plane of incidence. Leslie, and more perfectly Melloni and De la Provostaye and Desains, made a number of experiments on the reflecting power of bodies. The metals, though the best reflectors, differ among themselves, silver being the best, and iron the worst reflector. All polished metallic surfaces are good reflectors of heat, the reflecting power diminishing as the surface becomes tarnished or blackened. This fact has many familiar illustrations. Burning mirrors are constructed on the principle of the reflection of heat, the heat rays reflected from a concave mirror being brought to a focus just as is the case with the light. In roasting meat a polished metal screen is placed around the joint; the radiant heat from the fire, which otherwise would escape the joint, being reflected on to it by this means. The polished fire irons before a fire are never warmed by the heat radiated by the fire, because all the heat that falls on them is reflected from their surface. Besides being thus regularly reflected, a part of the heat which falls upon a surface is scattered in all directions, or, as it is termed, *diffused*. With rude apparatus Sir William Herschel examined the power of scattering heat possessed by various surfaces, and found that white paper scattered most heat and light, and black velvet least. The heat not thus regularly or irregularly reflected from a body is either absorbed by the substance being lodged within it, or transmitted through the body as light is transmitted through transparent substances. The *absorbing* power of a body is inversely proportional to its reflecting power, a good absorber being a bad reflector. On the other hand, the properties of absorption and radiation are reciprocal: the good absorber is a good radiator, or vice versâ. It follows from this that culinary vessels intended to receive heat should not be bright, but blackened; at the same time, vessels, such as urns and teapots, intended to retain heat, should not be of earthenware or painted, but of polished metal. We shall subsequently examine more

in detail the absorption of heat by various solid, liquid, and gaseous substances.

Like light, radiant heat can be *refracted* by means of suitable lenses. In the year 1800, Sir William Herschel first established the fact of the refraction of heat by a series of careful experiments. He converged the solar rays and the radiation from a heated stove by means of a glass lens, and found that there was a focus of heat a little beyond the focus of light formed by the lens. The *double refraction* of heat by a prism of Iceland spar was discovered by M. Bérard, who also was the first to announce the *polarisation* of heat. Employing more delicate apparatus, Principal Forbes subsequently verified this fact, using thin plates of mica for the purpose of polarisation. These facts were successively examined and firmly established by the experiments of Melloni. This philosopher has, however, gone further, and opened up an entirely new field of investigation, in the discovery that the invisible rays of heat possess different qualities like the differently coloured rays of the visible spectrum. Light which has passed through a glass of a certain colour, passes through another glass of the same colour far more freely than through any other coloured glass. The same phenomenon is exhibited by radiant heat; for, after passing through one plate, it will traverse with freedom a number of other plates of the same material, though it may not be able to pass through a plate of another substance. It follows, therefore, that the invisible rays of heat must differ in a manner analogous to the coloured rays of the spectrum. This heat-colouration Melloni named *thermocrosis*.

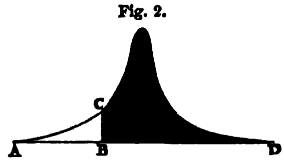
All the foregoing phenomena show the close relationship existing between radiant heat and light. No fact in the one is without its parallel in the other; and this wonderful coincidence has led philosophers to the belief that one is but a modification of the other: light consisting of undulations in the ether of a certain length which increases from violet to red, and radiant heat of similar undulations of a length greater than the red. This will be shown more clearly in the next section.

Heat of the Spectrum.—Sir William Herschel in the year 1800 examined the temperature of the different colours of the solar spectrum by means of delicate thermometers. He found the temperature to increase as he approached the red end: going into the obscure region beyond this point, he still found the temperature to rise; the thermometer indicating 7° Fahr. in the full red, whilst in the dark rays beyond the red it rose to 9° Fahr. By means of a linear thermo-electric pile, and a rock-salt lens and prism, Melloni made a series of accurate experiments on the heating powers of the solar spectrum, which corroborated Sir William Herschel's observations, and established the fact that the maximum temperature of the spectrum lay in the dark space beyond the red. Since Melloni's time, Prof. Müller has re-examined the solar spectrum, and represented the heating effect by the following curve, fig. 1. The luminous part of the spectrum is included within the space ABC,



whilst the non-luminous heat-rays are included in the dark space BCD. These dark rays are known as the extra or ultra red rays, or sometimes as the Herschelic rays. Very recently Prof. Tyndall has investigated with great care the spectrum of the electric light, using similar apparatus to that employed by Melloni. As in the solar spectrum, Tyndall found the heating effect to rise from the violet, where it was *nil*, to the red, and increase to a maximum in the dark space beyond the red. A graphical representation of the electric spectrum (fig. 2) was constructed as in the case of the solar spectrum. The distribution of heat in the two spectra are dissimilar, the extra-red rays BCD being largest in amount in the radiation from the electric light, and towering over the portion occupied by the visible spectrum ABC. It has, however, been proved by Tyndall that when a thin layer of water is interposed in the path of the rays of the electric light, the shape of the curve becomes similar to that obtained from the solar rays at the earth's surface. It is therefore probable that the diminution of the extra-red rays in the solar spectrum is

Fig. 2.



owing to their partial absorption by the aqueous vapour in our atmosphere, an hypothesis supported by recent observations.

The luminous spectrum is only the visible central part of the rays of the sun or the electric light decomposed by a prism, for innumerable dark rays fall beyond both ends of the spectrum. The invisible rays beyond the violet were first rendered visible by Prof. Stokes. [FLUORESCENCE.] Sir Wm. Herschel endeavoured to render visible the invisible rays beyond the red, by cutting off the luminous spectrum and condensing the extra-red rays by means of a lens. His attempt was unsuccessful, and it is only recently that this has been accomplished by Prof. Tyndall in the following manner. A concave mirror about five inches in diameter was placed behind the electric light, and its intense radiation thus converged to a focus about six inches distant. Between the luminous focus and the electric light was interposed a solution of iodine in bisulphide of

carbon contained in a glass cell two inches deep. This solution has the power of stopping all the light, i.e. of absorbing the rays A B C, fig. 2, whilst it transmits the obscure rays represented by B C D, fig. 2. An intensely hot but invisible focus was thus obtained, at which black paper could be inflamed, a cigar lighted, and the more fusible metals melted or burnt. When a piece of thin blackened platinum was held in the dark focus, it was immediately raised to a white heat; and thus the non-luminous rays beyond the red were rendered luminous, and the identity of the agent which produces light and radiant heat was established. To this phenomenon Prof. Tyndall has given the name *calorescence*.

Emission of Heat.—In the preceding section prismatic analysis reveals the fact that the larger portion of the radiation from luminous bodies consists of invisible rays of heat. To determine the actual ratio which exists between the light and heat radiated from a luminous source, it is only necessary to measure the total radiation, and then suppress either the luminous or obscure portion, by interposing suitable absorbents in the path of the rays. Melloni did this by cutting off the obscure heat by means of a layer of water, a liquid which he found impervious to the radiation from bodies heated under incandescence. More recently Tyndall has checked these determinations by withdrawing the luminous radiation by an opaque solution of iodine in bisulphide of carbon, and measuring the amount of obscure rays, which were wholly transmitted by this *ray filter*. Various sources examined in this manner gave the following proportion of luminous and obscure rays in every 100 emitted; the sum of both is, of course, the total radiation.

	Luminous	Obscure
Dark spiral	0	100
Red-hot spiral . . .	0	100
Hydrogen flame . . .	0	100
Oil flame	3	97
Gas flame	4	96
White-hot spiral . . .	4·6	95·4
Electric light . . .	10	90

Every luminous ray is converted into its equivalent of heat when it falls upon and is absorbed by the blackened face of the thermo-electric pile. Hence it appears that the calorific equivalent, or amount of force, corresponding to the luminous rays emitted from a hydrogen flame, or even a red-hot spiral, is absolutely insensible when compared with their obscure radiation; and that in the intensest artificial light only 10 per cent. of the whole emission consists of luminous rays. These remarkable facts must increase our admiration of the wonderful structure of the eye, as they show the extraordinary sensitiveness of the retina to the impression of light.

When various substances are raised to the same temperature, they do not all emit the same amount of heat. Leslie examined these differences in the radiating power of a great number of bodies. Coating the sides of a cubical canister (now known as a *Leslie's cube*) with various substances, he found that lampblack, white lead, and all organic bodies were the best radiators, whilst the metals were the worst. The radiating like the absorbing power of a body is exactly the reverse of its reflecting power: a good radiator is a bad reflector. With more delicate thermometric apparatus Tyndall has recently determined the emissive power of various powders, which were attached to the sides of a Leslie's cube heated to 212° Fahr. The radiation from the metal surface of the cube being equal to 15 units, that from other substances coating this surface is given in corresponding units in the following table:—

Substance	Radiation
Rock salt	35·3
Biniodide of mercury . .	39·7
Sulphur	40·6
Vermilion	46·6
Fluor spar	68·4
Carbonate of lime . . .	70·2
Red oxide of lead . . .	74·2
Oxide of cobalt . . .	76·7
Sulphate of lime . . .	77·7
Red oxide of iron . . .	78·4
Hydrated oxide of zinc . .	80·4
Lampblack	84·0

As these substances are of different colours, the experiments are a test of the influence of colour on radiation. At this temperature colour is seen to be without any effect on the radiative power; for the feeblest radiator, rock salt, and one of the most powerful, oxide of zinc, are both white; biniodide of mercury and oxide of lead are both red, but their radiating powers are very different.

Absorption of Heat.—Melloni laid the foundation of this branch of radiant heat by a careful and elaborate investigation of the transmission of heat through solids and liquids. The solid substances examined by him were cut into plates 0·1 of an inch thick. After noting the effect produced by the radiation from this source when nothing intervened, the little plate was interposed, the diminution which it effected being then observed. Melloni successively tried four different sources of heat, determining in each case the transmission through the same bodies.

	Oil lamp	Incandescent platinum	Copper at 750° Fahr.	Copper at 212° Fahr.
Rock salt	8	8	8	8
Sulphur	26	23	40	46
Fluor spar. . . .	28	31	58	67
Rock crystal . . .	62	72	94	97
Glass	61	76	94	100
Black glass . . .	74	75	88	100
Common gum . . .	82	97	100	100
Alum	91	98	100	100
Ice	94	100	100	100

If the total radiation from each source be represented by 100, the numbers in the foregoing table express the proportional quantities of heat intercepted by some of the principal substances examined; showing that different bodies, though they may be of equal transparency to light, possess very different powers of transmitting heat, and that with one exception the heat of the different sources is transmitted in different degrees by the same body. To express the power of transmitting heat, Melloni gave the name *diathermancy*; whilst the power of intercepting heat he called *athermancy*. Melloni made rock salt perfectly diathermic for all sources of heat; the 8 per cent. which it failed to transmit he attributed to loss by reflection from its surfaces; but a stricter examination by Tyndall has discovered that even rock salt absorbs a small proportion of obscure rays. The table shows that a transparent plate of glass one-tenth of an inch thick intercepts all the heat radiated from a cube of boiling water, that a plate of alum of equal thickness is opaque to all bodies heated under incandescence, and that a similar film of ice transmits only 6 per cent. of the radiation from an oil lamp. As ice is perfectly transparent to light, the reason for its opacity to the heat of the red-hot spiral, and its small transmission of the heat from the lamp, becomes explained by reference to the last section, where it is shown that in all luminous sources the light rays bear a very low ratio to the obscure.

Melloni also examined the transmission of heat through *liquids*. These he enclosed in a little cell with glass sides; the thickness of the liquid layer was 0·36 of an inch, and the source of heat an oil lamp surrounded by a glass chimney. Out of every 100 rays Melloni found,

Bisulphide of carbon absorbed	37
Olive oil	70
Naphtha	72
Ether	69
Sulphuric acid	83
Nitric acid	85
Acetic acid	88
White of egg	89
Water	89

These numbers express the absorption by the liquid *plus* the absorption by the glass sides of the cell, which latter, from the quality of the heat employed, must have been large.

As besides this the experiments of Melloni are not entirely free from error, Professor Tyndall has recently determined with more perfect apparatus the transmission through liquids. The source of heat here employed was a spiral of platinum wire, which was raised to a bright red heat by the passage of an electric current. The liquids were enclosed in a cell with movable rock-salt sides, so that liquid layers of varying thickness were obtainable. In the following table are given the absorptions per cent. of different liquids at the thicknesses mentioned.

	Thickness of liquid in parts of an inch		
	0·02	0·07	0·27
Bisulphide of carbon	5·5	12·5	17·3
Chloroform	16·6	35·0	44·8
Benzol	43·4	62 5	73·6
Ether	63·3	76·1	85·2
Alcohol	67·3	83·6	89·1
Water	80·7	88·8	91·0

As in the case of solids, large differences are seen to exist between the absorbent power of various liquids. Though all the substances in the foregoing table are transparent to light, yet between the first and last in the list a difference of more than 75 per cent. exists in the power of transmitting heat.

The elegance of Tyndall's arrangement was further shown in his perfect control over the temperature of his source. This he could elevate by merely increasing the strength of the electric current which passed through the spiral. The temperature being thus gradually raised from below incandescence to vivid whiteness, the proportion of heat transmitted was found steadily to increase. This Melloni had previously discovered, deducing from his observations a law that the penetrative power of radiant heat increases with an increase of temperature of the source. But, whilst the experiments just mentioned confirm this law, Knoblauch and more lately Tyndall have shown that it is not in all cases true. For example, the latter found that of the radiation from a hydrogen flame 99 per cent. was absorbed by a layer of water 0·07 inch in thickness, and the whole radiation was entirely intercepted by a layer of water 0·27 of an inch thick. With a red-hot spiral, though the temperature of this source is far lower, layers of water at the same thicknesses absorbed 89 and 91 per cent. respectively.

But besides solids and liquids, *gases* and *vapours* are found to absorb very marked and different amounts of radiant heat. Tyndall has entirely created this branch of investigation. To him we owe the discovery and laborious examination of the absorption of heat by gaseous bodies. The limits of this work forbid a description of the apparatus employed in these experiments; we shall therefore merely give a summary of the results obtained. It was found that oxygen, hydrogen, and nitrogen, or a mixture of these gases, absorb an inappreciable amount of heat, whilst many of their gaseous combinations were powerful absorbents. The following table gives the absorptions by various gases relatively to the amount of heat intercepted by air, which was taken as unity. The gases were successively allowed to fill a glass tube nearly three feet long, the source of heat being a plate of copper heated by a gas flame.

	Relative absorption
Air	1
Oxygen	1
Nitrogen	1
Hydrogen	1
Chlorine	39
Carbonic acid	90
Sulphurous acid	710
Olefiant gas	970
Ammonia	1195

Subsequently Professor Tyndall examined some of these gases contained in a brass tube fifty inches long, using the same source of heat as before. The results given in the next table are absolute absorptions, the total radiation through the exhausted tube being taken as 100.

	per cent.
Carbonic oxide absorbed	13
Carbonic acid	14
Nitrous oxide	33
Olefiant gas	77

Preserving the experimental tube of the same length, Professor Tyndall has first examined the effect of diminishing the pressure of the gas within it; and then, keeping the pressure of the gas constant, he has investigated the effect of diminishing the length of the gaseous column. In the first case, up to a certain point the absorption was found to be exactly proportional to the density of the gas; but in the second case, even with the thinnest layers, the absorption generally increased less rapidly than the thickness. Four gases were submitted to experiment, the length of their columns being gradually increased from 0·01 of an inch up to 50 inches.

A layer of olefiant gas 0·01 of an inch thick absorbed nearly 2 per cent. of the radiation from a heated plate of copper, a column of the same gas 2 inches thick intercepted about per cent., and a column 2 feet thick absorbed nearly 70 per cent.

The absorption by vapours has also been examined, and as great differences found to exist among these bodies as among gases. The liquids from which they were derived were contained in a little flask, and each vapour was admitted into the tube until a pressure of half an inch was indicated by an attached barometer gauge. Here are the results with the same length of tube and the same source of heat as employed in the measurements given in the last table:—

	per cent.
Bisulphide of carbon vapour absorbed	8
Chloroform	17
Benzol	20
Alcohol	47
Ether	53
Acetic ether	64

Hence the vapour of chloroform, one of the feeblest, at a pressure of $\frac{1}{60}$ of the atmosphere absorbed more heat than a whole atmosphere of carbonic acid gas. The vapour of water could not be examined directly as the other vapours, but numerous experiments conducted in other ways showed that this of all vapours was probably the most powerful absorbent of heat. The importance of this fact as explaining many perplexing phenomena in meteorological science will be at once evident.

Perfumes have been subjected to examination by Tyndall, and the absorption by various kinds have been measured. The odour of patchouli absorbed the least heat, and of spikenard and aniseed the most. The almost inappreciable quantity of matter contained in these odours, and yet their strongly marked action on radiant heat, is a striking and suggestive fact.

A strict comparison of the absorption of heat by certain liquids and by proportional quantities of the vapours derived from them, showed that the order of absorption was in both cases the same. The position of a liquid as an absorbent is the same as that of its vapour, and hence it is probable that from these experiments the general law can be deduced that the relative power of absorption possessed by any body is independent of its state of aggregation.

The *radiating* powers of gases and vapours have been investigated by Tyndall. The method chiefly employed was very novel, and consisted in making the gas, whose radiative power was to be determined, heat itself by rushing into the vacuous experimental tube. The particles of the gas were warmed by their impact against the tube, and radiated their heat to the pile. In these experiments both sources of heat were removed, and the end of the tube remote from the pile was closed by a plate of metal, the rock-salt plate remaining at the other end. In this way Tyndall has demonstrated that the radiative power of every gas or vapour is directly proportional to its absorptive power: an important extension of that law which was first proved, in the case of solids, by the experiments of Leslie.

Radiant Point of Shooting Stars. [METEORS, LUMINOUS.]

Radiants. In Geometry, straight lines of unlimited length proceeding from a point. The term *pencil of rays* is more frequently employed to denote the same thing. [PENCIL.]

Radiaries. [RADIATA.]

Radiata (Lat. radius, *a ray*). The name given by Cuvier to the lowest organised of the primary divisions of the animal kingdom; because certain of the animals therein included have a radiated form of a part or the whole of their body. [ACRITA; NEMATONEURA; PROTOZOA; ZOOPHYTA.]

Radiating Point. Any point from which rays of light or heat proceed.

Radiation (Lat. radiatio, from radius, *a ray*). The emission of light or heat from a luminous or heated body. The principal laws of radiation have already been given under the article RADIANT HEAT; but the subjects included under the present head are more particularly the phenomena of solar and terrestrial radiation.

The force of solar radiation is measured by the excess of the temperature which a body assumes when exposed to the direct action of the sun's rays above that which it has when turned towards space away from the sun. This excess may be roughly determined by two common thermometers, one placed in the shade, and the other exposed to the sun and having its bulb blackened to prevent reflection. A more accurate means was, however, devised by Sir John Herschel, who, with an instrument called by him an *actinometer*, has measured the heat received from the sun at the Cape of Good Hope. M. Pouillet has also executed a series of measurements on solar radiation, employing for this purpose an instrument which he named a *pyrheliometer*. By these experiments the amount of solar heat falling in a given time on a surface of known area was ascertained, from which the value of the heat which the earth annually receives from the sun was deduced. This amount is equal to that which would melt a stratum of ice 102 feet thick encrusting the whole earth. Having found the quantity of solar heat intercepted by the earth, the entire amount emitted by the sun can be calculated. This is 2,300,000,000 times more than we receive, it would boil 700,000,000,000 of cubic miles of ice-cold water per hour, and in one year it is equal to the heat produced by the combustion of a layer of coal seventeen miles thick entirely surrounding the sun.

The amount of heat received from the sun diminishes as the thickness of the air traversed by the sunbeams increases. When the sun is at the horizon the absorption by our atmosphere is therefore greatest, when at the zenith it is least. In this latter position M. Pouillet estimated our atmosphere absorbed 25 per cent. of the solar radiation; but a far higher proportion of terrestrial radiation is intercepted. This has been established by Professor Tyndall, who has discovered that the main absorbent in our atmosphere is not the large body of oxygen and nitrogen of which it is composed, but the small amount of aqueous vapour it always contains. The presence of aqueous vapour in the air is thus shown to be of essential importance in climate.

While the earth is receiving heat from the sun, it is continually radiating its own warmth into space. This loss is more than compensated during the day, but at night the terrestrial radiation causes the condensation, and sometimes the congelation of the moisture in the air. Dew in summer and hoar frost in winter are thus produced on the surfaces of those bodies which are the best radiators, such, for example, as are all animal and vegetable structures. From the theory of terrestrial radiation, a curious deduction was made by Fourier, with regard to the temperature of the region of space through which the earth moves in its orbital revolution: this he estimated to be $-58°$ Fahr., but Pouillet has more recently made the temperature of space to be $-175°$ Fahr.

Radical. [ORGANIC RADICALS.]

Radical Axis of Two Circles. Two conics intersect one another in general in four points, and have, consequently, six common chords. In the special case of two circles four of these chords are always imaginary, and one at infinity [CIRCULAR POINTS AT INFINITY]; the fifth, and only remaining common chord, however, is always real, whether the circles intersect or not, and is called their *radical axis*, a name proposed by Gaultier of Tours. (*Journal de l'École Polytechnique* 1813.) One of the characteristic properties of the radical axis, which leads at once to its construction in the case of two non-intersecting circles, is that the tangents to the two circles drawn from any point of it are equal. Circles having the same radical axis are said to be *co-axal*; they possess many remarkable properties. The circles of a co-axal system will either intersect each other in the same two points, or not intersect at all. In the latter case there will be two *point circles* in the system; these are called the *limiting points*. Every circle whose centre is in the radical axis, and which cuts one of the co-axal circles perpendicularly, cuts all in the same manner: all circles thus drawn constitute a second *conjugate* system of co-axal circles whose common radical axis is the line of centres of the first system. Of two such conjugate systems of co-axal circles one has always limiting points and the other not. The inverse circles to those forming a co-axal system are also co-axal, and their reciprocals form a system of confocal conics. In the works of Poncelet, Chasles, and Steiner, as well as in the more recent English text-books and journals, the properties of co-axal circles are frequently discussed.

Radical Bass. In Music, the same as FUNDAMENTAL BASS.

Radical Centre of Three Circles. The point of intersection of the three radical axes of the circles, taken in pairs. It is the centre of the only circle which can be drawn to cut each of the three circles orthogonally.

Radical Reformers. In Politics, a name applied to that political party in England which desires to have the abuses which, from lapse of time or any other cause, may have crept into the government, completely *rooted out* (as the term implies), and a larger portion of the democratic spirit infused into the constitution.

Radical Sign. In Algebra, the symbol $\sqrt{}$, denoting the extraction of a root. It is a modification of the letter *r*, the initial letter of *radix* or root. To distinguish the particular root which is to be extracted, a number is prefixed to the symbol; thus, $\sqrt[2]{}$, $\sqrt[3]{}$, $\sqrt[4]{}$, &c. denote respectively the square root, cube root, fourth root, &c.; but as the square root or second root was the first considered, the number is usually omitted, and merely the symbol $\sqrt{}$ written. Fractional exponents are frequently used instead of the radical sign. A *radical quantity* is a quantity to which the radical sign is prefixed.

Radicle (Lat. radicula, dim. of radix, *a root*). In Botany, that portion of an embryo which eventually becomes the descending axis or root. It is the lowest of the two opposite cones of which an embryo plant consists.

Radiolite. A variety of Natrolite from Brevig, in Norway.

Radiolites. A genus of fossil shells, the inferior valve of which is in the shape of a reversed cone, the superior valve being convex.

Radius (Lat.). In Fortification, the *oblique radius* is a line drawn from the centre of the polygon to the extremity of the exterior side; the *right radius* is a line drawn from the same centre perpendicular to the exterior side.

RADIUS. In Geometry, the line drawn from the centre of a circle to any point in its circumference.

RADIUS. In Osteology, a bone of the fore-arm; so called from its supposed resemblance to the spoke of a wheel. Its upper end, which is the smallest, is formed into a round hollowed head, and is articulated with the small head at the side of the pulley of the humerus, whilst the rounded border of it next the ulna is articulated with the lesser sigmoid cavity of that bone; its lower extremity is articulated with the bones of the wrist.

Radius of Curvature. The radius of the circle of curvature. [CURVATURE.] The length of the radius of curvature at any point of a plane curve, whose equation to rectangular coordinates is $f(x, y)=0$, is

$$\frac{(dx^2+dy^2)^{\frac{3}{2}}}{(d^2x\,dy-d^2y\,dx)}$$

which expression becomes simplified when x is taken as the independent variable and regarded as equicrescent, as then $d^2x=0$. If the curve be referred to polar coordinates r and θ, the radius of curvature is given by the formula

$$\frac{(dr^2+r^2d\theta^2)^{\frac{3}{2}}}{r^2d\theta^3+rdr\;d^2\theta+2dr^2d\theta-rd\theta d^2r}.$$

Radius of Explosion. In Military Mining, the line drawn from the charge to the edge of the crater.

Radius of Rupture. In Military Mining, the distance from the charge to the point at which the internal commotion caused by the explosion ceases.

Radius of Torsion of a Non-Plane Curve. [TORSION.]

Radius Vector (Lat. radius, and vector, *one who carries*). In Geometry, the line joining a fixed point or *pole* to any other point in space. The length of the radius vector is one of the *polar coordinates* of the point. [COORDINATES.]

Radix. In Mathematics. [ROOT.]

Raft (Dan.; A.-Sax. reaflan). A species of float formed of various logs or planks, fastened together side by side, so as to be conveyed from one point to another. This means of conveying timber to the sea-coast is practised in many places. The following is the plan adopted on the Rhine. A little below Andernach the village of Namedy appears on the left bank under a wooded mountain. The Rhine here forms a bay, where the pilots are accustomed to unite together the small rafts of timber floated down the tributary streams into the Rhine, and to construct enormous floats, which are navigated to Dordrecht, and sold. These machines have the appearance of a floating village, composed of 12 or 15 little wooden huts, on a platform of oak and deal timber. They are frequently 800 or 900 feet in length, and 60 or 70 in breadth. The rowers and workmen sometimes amount to 700 or 800, superintended by pilots, and a proprietor. The raft is composed of several layers of trees, placed one on the other, and bound together: a large raft draws not less than 6 or 7 feet of water. Several smaller rafts are attached to it, by way of protection, besides a string of boats loaded with anchors and cables, and used for the purpose of sounding the river and going on shore. The domestic economy of an English man-of-war is hardly more complete. Their navigation is a matter of considerable skill, owing to the abrupt windings, the rocks, and shallows of the rivers.

Rafts improvised of spars, barrels, planks, &c. often afford valuable aid in saving life and property in cases of shipwreck. For such purposes carefully bunged casks offer greater powers of flotation than almost any article on board ship.

RAFT. In Military Engineering, a floating movable bridge, consisting either of strong pieces of wood secured together, and covered with planks or boards, in which case it will not bear much weight; or of the same arrangement with casks secured underneath, when artillery can be passed over it.

Rafter (Sax. ræfter). In Architecture, an inclined piece of timber in the side of a roof; sometimes called a *spar*. [ROOF.]

Rag Stone. A dark grey silicious sandstone breaking with a rough or ragged fracture.

Ragman's Roll. A name of which no authentic derivation is extant (Jamieson's *Etymological Dictionary*), but which belongs to the collection of instruments by which the nobility and gentry of Scotland subscribed allegiance to Edward I. in 1296. They were preserved in the tower of London; and have been printed by the Bannatyne Club (1834).

Raguly (apparently from the Fr. ragué, used of a rope fretted by rubbing). In Heraldry, a line jagged or notched in an irregular manner. The old cognisance of the Nevilles, the *ragged staff*, is a *bâton raguly*.

Rail (Ger. riegel). In Architecture, the horizontal part in any piece of framing or panelling. Thus in a door the horizontal pieces between which the panels lie are called *rails*, whilst the vertical pieces between which the panels are inserted are called *styles*.

Rail or **Water-Rail** (*Rallus aquaticus*, Linn.). A native species of a genus of Macrodactyle or long-toed waders, destitute of alar spines or a frontal shield.

Railing. A fence or barrier made of posts and rails, whether of wood or iron. The most ordinary fence of this description in the country is formed of wooden posts let into the soil, so as to stand upright, to which are nailed or mortised horizontal wooden rails, one above another, at such a distance as to prevent domestic animals from penetrating through them. In some cases one horizontal rail is fixed to the posts near the ground, and another near the top of the post, the interval between them being rendered impenetrable to cattle by upright rails nailed to the top and bottom horizontal rails. Iron railings are generally formed in this manner, i.e. the bars are riveted to the bottom horizontal rail, and fixed to the upper rail by lead or any other contrivance.

Railroad or **Railway.** In Political Economy. The charge of carriage is one of the most important items in the cost of production and the distribution of commodities to consumers. So considerable is it in some cases, that bulky articles, however cheaply made in some countries or districts, cannot be transported even to regions where materials are scanty and labour dear, but must be manufactured on the spot. Every country, for instance, has common pottery works, and manufactures at least the cheaper kinds of wooden furniture. Under no circumstances would it be advantageous to add the cost of conveyance to the production of these articles, even though they could be supplied under the most favourable conditions. Similarly, some articles possess so much value in small bulk—as, for instance, precious metals, precious stones, and spices—that the cost of carriage becomes a comparatively small element in the aggregate price of the utility offered to the consumer. It is possible that, with due appliances of artificial heat and horticultural skill, every one of the spices produced in tropical countries could be grown under glass in England. But the increased cost of production would be so considerable, that no one would attempt the cultivation, unless for scientific purposes. Between these two classes of commodities, those which could not be carried because the cost of transit forms so large an element in the price, and those which would be carried under even the most imperfect means of transit, there is a very large class of objects, which if the cost of carriage be considerably reduced might be got from countries or regions in which they can be produced most cheaply, and thus their manufacture in countries where they are produced at greater cost might be superseded. Again, in the case of those commodities which are produced abundantly in one country, and not produced at all in another, but are nevertheless in demand, a reduction of the cost of carriage will bring their use within the power of those who have hitherto by reason of their dearness been debarred from the enjoyment or convenience. Thus, for instance, pepper is produced in certain tropical countries as profusely as haws are on English hedges, and from the remotest times has formed an ingredient almost necessary in cookery. Before the discovery of the Cape passage, pepper was carried by a tedious land passage across the plains of Central Asia to the coast of Syria, or through the highlands of Armenia to Trebizond, or by a sea passage (scarcely less expensive) from Ceylon to Aden, thence across the desert of the Nile, and down this river to Alexandria; hence it cost, when sold in England, about 1*s.* 6*d.* the pound troy, i.e. fully 10*s.* or 12*s.* in present values: or, to take a nearer case, there is no reason to believe that the price of tea is materially changed in China since the time, now about 180 years ago, when it first became an article of general consumption in this country. If any effect has been produced by the long-continued traffic, it naturally should be that of an increased charge. But so considerably has the comparative cheapness of carriage reduced the price of this article, that the same tea which in the days of the East India Company's monopoly and the slow voyaging of her sluggish merchantmen, cost 12*s.* the pound in England, may now be had for 2*s.* Lastly, since duties are and have been levied on the most important articles of foreign produce, especially those which are in a state immediately available for consumption, and since, in order to make the tax as light as possible to the consumer, the duty is paid at a time as near as possible to that in which the article is consumed, the existence of an easy system of transit and carriage will bring about that the least possible amount of duty-paid goods will remain in the hands of the retail trader, and thus that he will be enabled to offer his commodities at the lowest possible rate to the consumer. [SUPPLY; WAREHOUSE, BONDED.]

Now, overland, the charge of transit must, from the friction to be overcome, be vastly greater than that imposed on sea-borne goods. Even when a canal has been made, and great outlay incurred in making levels, building locks, and securing the sides of a canal from leakage, the reduction of cost is very great, in consequence of the vast diminution of friction by the use of water carriage. It will be obvious, too, that if a road could be constructed in which friction could be completely eliminated, and the only remaining difficulty to be overcome would be the resistance of the air, very little mechanical or manual force would be needed in order to move heavy weights over the plane surface, while by implication the reduction of such an amount of friction to the least amount would progressively approximate to the condition of an absolute removal of friction from the act of artificial motion, and the economical end, often adverted to, of attaining the greatest possible result with the least possible expenditure of force, would thus be reached. The advantage of using a plane surface was, of course, felt as soon as manual or other labour was employed in moving heavy bodies, and the act by which a

labourer drives a wheelbarrow up or along a plank has fundamentally the same purpose as the use of a tram or railway. These trams or railways have existed in mining and quarrying districts for a long time, and it is said that the duke of Bridgewater, of canal reputation, was aware that the only practical competition which could hereafter militate against his favourite method of canal traffic was the railway.

The course of scientific discovery and adaptation, which has developed the stationary into the locomotive engine, has produced a complete revolution in the means of land transit, both as to cheapness, efficiency, and speed. The conveyance of goods, which under the old system of heavy waggons, or the improved but imperfect method of canal navigation, was very long, necessarily very incomplete, and generally very expensive, has now been rendered easy and rapid, the time of transit having been diminished by one-fifth at least, and the service of the railway being much more general than that of canals. The cost, too, though not lessened in the same proportion, is considerably reduced. It is true that in the conveyance of heavy goods, the demand for which is pretty constant and the supply generally uniform, the slowness of canal traffic is no hindrance to business, and the barge can still compete successfully with the locomotive. But in the conveyance of all commodities for which speed is necessary, and occasionally even for the conveyance of the most bulky goods, the railway is superior to any other method of transit. For example, under the old canal system, a continual frost often produced a sort of coal famine in large towns, as well as other results now obviated by the services of railroads. The first advantage, then, which a railroad gives to trade, and by implication to the producer and consumer, is that it diminishes the cost of transit. This result, which is manifest enough in those objects which are immediately familiar to us, is of the highest national importance when we take into account its effects on home and foreign trade. The fertility, for instance, of any district, will be of very little value to its possessors, unless an easy method be supplied by which its produce can be brought to market. A good road is as great an object of interest to the agriculturist, as good cattle and good land. The real value of any estate, as far as the market price of its produce goes, is greatly relative to the ease and cheapness with which that produce can be offered for sale. In this particular, railroads have conferred prodigious benefits on landowners. They have at once equalised and raised prices. The market value of costly but perishable commodities has been almost doubled in certain districts by their operation. The stimulant given to production in the creation of a market for produce is very great. Meat, poultry, fish, fruit, vegetables, milk, butter, eggs, and a variety of other products, the consumption of which was once almost entirely local, and the price of which was consequently low, are now rated even in remote country places at town prices. Twenty or twenty-five years ago, legs of pork, the least valuable part of the pig with agriculturists in home consumption, could have been frequently purchased in the eastern part of Hampshire at from 3½*d.* to 4*d.* the pound, while fresh butter in summer rarely rose above 8*d.* the pound. These and similar low prices of poultry and fruit have been raised by the easy method of transit supplied by railroads. In all probability (for the elements of the calculation are wanting, owing to the absence of any compulsory registration of the titles to landed property), land in the neighbourhood of railways, i. e. the greater part of the land in England, has increased seventy-five per cent. in value, by this cause alone, during the last thirty years.

The effects of railways on foreign trade are still more noteworthy. Many conveniences and luxuries of life have been rendered accessible to the community by the beneficent agency of these iron roads. For instance, a great trade in foreign eggs and fruit is being carried on between this country and France. Such a trade would be impossible without easy and rapid communication. At the present moment a traffic is springing up in ripe grapes, brought from the South of France, the purpose of the importation being the use of these articles for the home manufacture of wine. No better illustration could be given of some of the advantage which may and does ensue upon the distribution of commodities and the division of human labour, than the introduction of such a traffic by the agency of a railroad.

Still more important, however, is the effect of railway communication on the supply of food. It is a continual subject of alarm among economists, that population in thickly settled countries is fast outgrowing the means of subsistence. This view is based partly upon the economical theory of Rent, partly on that of Population. But the contingency, on the hypothesis of sustained intercourse taking place between communities, and the strengthening of international interests, is so remote as hardly to deserve serious attention, still less to be a subject of alarm. Improvements in the conveyance of supplies by ships, in the shortening of voyages, the cheapening of materials, the abolition of duties on timber, are doing and will do much towards lessening the cost of food produced in countries where fertile land is boundless, and the cost of agriculture, as proved by the price of corn on the spot, is very low. But railroads have done even more than ships towards bringing about this result, and dispelling the alarms of those who have hitherto reasoned from imperfect data. If the reader will cast his eyes upon any map of the United States, and consider the network of railroads converging to Chicago, Detroit and Buffalo, and observe that they form a sort of trade drainage for the produce of the vast prairie lands in the western states; that railroads are laid as rapidly as their areas are

being brought into cultivation; that it pays the western farmer well to produce wheat for the English market at prices far below the average of those at which it was cultivated prior to the liberation of food from the trammels of the corn laws; and that the emigration into the United States, and the occupation of land, are progressing at a rate unparalleled in the history of any community which has ever grown before, the alarm of a deficient supply and a redundant population will be seen to be as baseless as any panic which has ever occupied men's minds. And it must be remembered that this area is only a portion of that which is being cultivated for food. The best districts of Canada are being rapidly occupied, and wheat of the best quality grown. The supply from these regions promises to be exceedingly abundant; for it is a fact in the culture of wheat, that its quality is always the better the nearer it approaches the isothermal line beyond which its cultivation is, by climatal reasons, impossible.

The economical history of railway enterprise in this country is by no means creditable to the national character or the public conscience. It could not, perhaps, have been expected that these undertakings should have been the act of government, not so much because they are not (like the post office) a branch of business which might have been very fairly carried out by government, but because administrations are inveterately prodigal, slovenly, and inefficient. The management, too, of railways in the hands of government would have been fruitful in all kinds of parliamentary and party jobs, and public opinion would probably have done little towards correcting abuses. Nor was it possible, according to the theory of property in land, and the permission given to landowners by the legislature to tie up and control its distribution by all sorts of complex conveyances, to construct these roads on the basis of mutual consent, or the consent of the majority of those through whose lands the railroad was to pass. Hence the purchase was compulsory, and effected by parliamentary sanction. But as the legislator was generally the landowner, it was necessary that terms should be made with him before his assent was given, and thus the landowners on various pleas contrived to exact enormous sums, under the name of compensation, for permission to use a part of their land, and, as events showed, to improve materially the remainder. It would be a curious enquiry to contrast the real value of the land taken for railways, and the price paid during the early years of these enterprises for the permission to take it. Now, as a considerable portion of the capital created by the companies was expended in these compensations and bribes, and no actual value was received for the concession—in other words, as much of the stock was virtually fictitious, it became the immediate interest of the companies to oppose any scheme which seemed likely to diminish the existing profit by competition. It was the interest of landowners to encourage such rivalry, and it was very plausibly alleged that as the parliamentary sanction had been obtained at the company's cost and represented a large sum in the company's liabilities, it should be defended and protected against the aggression of rival schemes. It has thus come to pass, that the principle of protection has been to a large extent recognised in railway undertakings, and every session large sums have been expended by the companies in defence of privileges which seem to be just, because they have been largely and fully paid for. Had the market value been given for land at the outset, and compensations been accorded for real injury only, subject, in case of provable benefit hereafter, to a corresponding reduction, the whole system of parliamentary attack and defence would have been exploded as irrational, unjust, and contrary in the fullest sense to public policy.

Nor is this all that railways have been liable to. After the great lines had been constructed, the system of branches was begun, and a different set of tactics was employed. It was found out that a railway was a benefit, but the shareholders of the old companies knew that the construction of these small lines would be an inevitable loss. They were constrained to make them, or imagined that they were constrained to make them, or purchased them when constructed on very advantageous terms to their temporary and sagacious owners. The writer was informed some time since, when enquiring of a leading director in one of the greatest English railways, that in no case had the company failed to suffer a serious loss by these transactions, and that had they seen a way of escape, they would never have entered into these negotiations. The whole of this loss is the fruit of the parliamentary system of railway enterprise, and of the waste of capital consequent on the incidents of that system.

When railways were constructed, parliament sanctioned a vast number. The old map in *Bradshaw's Guide* contained for some time projected railways as well as those which were constructed or in course of construction. It is hardly necessary to say that such a sanction, on the understanding that government was competent to decide upon the powers possessed by the company, was the ridiculous misconception of the amount of capital available for these works. The annual savings of the country are reckoned at seventy millions—a sanction was given for an outlay of six times this amount in a single year.

The Acts under which railways are governed generally provide that when the profit exceeds ten per cent. the excess should be accumulated, or fares should be reduced, or some public use should be made directly or indirectly of the surplus. Government has also reserved to itself the right of purchasing railways; and as means of public transit, assumes, properly enough, a right of action with them in public emergencies. But the causes noticed above have put out of sight the possibility of the government maxi-

mum rate of profit. The interest on the aggregate of railway stock is, and probably always will be, rather lower than the dividends on consols, the fares and rates being notwithstanding higher than in any country, though they should have been under a sounder system much lower. For information on the early history of English railways, see Mr. Francis *On Railways*.

The estimate of the average cost of conveying a train a mile is as follows:—

	s.	d.
Maintenance of way and works	0	5½
Locomotive power	0	9
Repairs and renewals of carriages and waggons	0	2¼
General traffic charges	0	9
Rates and taxes	0	1¼
Government duty	0	1
Compensation for personal injury, and damage and loss of goods	0	0½
Legal and parliamentary expenses	0	0½
Miscellaneous working expenditure not included in the above	0	2
	2	7

On the hypothesis that a train conveys 25 carriages, all of which are full, it follows that each passenger can be conveyed 100 miles at an average cost of something less than threepence farthing. The lowering of fares, reduced sometimes under circumstances of rivalry and competition to one-eighth of the ordinary charges, has not been found to cause a loss of more than *half per cent.* in the dividends.

These remarks apply with equal force to the carriage of goods. It has been shown that coals can be bought at the pit's mouth in some districts and conveyed to London at a total cost of seven or eight shillings a ton; but under the existing system the price paid for each ton on reaching its destination is quadrupled. A bill was recently sought for by the Great Eastern Company, who proved that the easiness of the gradients on the proposed line would so lessen the cost of construction and the expenses of working as to enable them to bring coals to London in any quantity at a shilling a ton. The bill was rejected on the very ground of this anticipated ability of carrying coals in trains of 400 tons load, profitably, at the rate of one farthing per ton per mile, the chairman remarking that it was not fair to other companies that they should be able to work at so low a rate.

On the other hand, the raising of fares is generally followed by a diminution in the returns. The receipts per train at a penny fare from Shrewsbury to Upton Magna were, in December 1858, 11*l.* 15*s.* 8*d.*; but on the return to a fare of threepence halfpenny in November 1859, the receipts per train fell to 4*l.* 4*s.* 11*d.*

For further details on this subject, and for the arguments in favour of converting the railways into government or national property, the reader is referred to an article on 'Railway Reform' in the *Westminster Review*, April 1866.

Railroads or **Railways.** Roads constructed of tracks of iron called *rails*, on which roll the wheels of carriages drawn either by horses or by steam engines, and to which they are confined by ledges or *flanges* raised on the tires of the wheels.

Theory of Railways.—The object to be attained by the construction of roads of every kind is to effect the transport of loads by the least possible expenditure of tractive force; and one road is better or worse than another, cæteris paribus, according as the same moving power is capable of drawing upon it a greater or less amount of load, or a given load at a greater or less speed. Since the moving power, whatever it may be, is expended in overcoming the resistance which the carriages on which the load is borne offer, this object can be attainable only by the adoption of such expedients as will permanently diminish the amount of that resistance; and common roads, canals, and railways, which are all expedients for diminishing the resistance of traction, have each their appropriate sphere. Common roads are suited for moderate amounts of traffic, and for the miscellaneous purposes of domestic communication. Canals are best for carrying cheap and heavy articles at a low speed; and railways are proper where there is a large traffic, and where a high rate of speed is required.

History of Railways.—About the middle of the seventeenth century, the transport of coals from the pits to the harbour was effected in the coal districts of Northumberland and Durham by laying down parallel tracks of timber with a horse path between them, the wheels being confined upon the beams or rails of timber by ledges or flanges projecting from the inside of the tire of the wheels. These timber rails were constructed in pieces of about 6 feet long with a section of about 4 inches square; they were supported on pieces of timber called *sleepers* laid at right angles to them transversely on the road. These sleepers were laid at about two feet apart, so that each pair of parallel rails was supported by three sleepers. Besides giving support to the rails, these sleepers had also the effect of maintaining the rails in gauge, or in keeping them at a fixed distance asunder. The rails were fastened to the sleepers by pins driven quite through the rails, and half-way through the sleepers. To preserve the uniformity of the upper surface of the rail, these wooden pins were planed off at the top.

The necessity of giving room for the flanges of the wheels, running as they did below the surface of the rail, and the small depth between the surface of the rail and the sleeper, rendered it impossible to protect the sleepers effectually from the action of the horses' feet by any covering of gravel or other material. The sleepers were consequently subject to great wear and tear. The rails also, being worn by the action of the wheels still more rapidly than the sleepers, required to be frequently replaced; and as each new rail was pinned down

to the same sleeper, the ends of the sleepers were gradually perforated by so many holes that the sleepers were weakened and required to be soon replaced. These defects were remedied by the adoption of the double-timber railway, which consisted in laying upon the surface of the timber rails, above described, additional rails of timber of equal scantling, attached to the lower rails by wooden pins, passing quite through the upper and half through the lower rails, in the same manner as the lower rails themselves were attached to the transverse sleepers. This change was attended with many advantages. Besides the increased strength given to the rails by the double timbers, the depth of the sleepers below the upper surface of the superior rail allowed the sleepers to be protected from the action of the horses' feet by covering them with broken stones, gravel, or other road materials. The structure of rails and sleepers also being stronger and more weighty, and held down by the road material with which the sleepers were covered, allowed a packing or ballasting to be driven under the rails, so as to give greater stability and firmness to the road. Another advantage obtained by this arrangement was, that when the superior rails were worn by the action of the wheels, they could be replaced by new ones without disturbing the inferior rails; and as the places of the joints, and those at which they were attached by pins to the inferior rails, could be varied at pleasure, the pin-holes made in the inferior rails would not come in the same place, or near each other, so as injuriously to weaken the latter.

The next improvement consisted in the addition of a plate or bar of iron, about two inches broad and half an inch thick, laid along the upper surface of the superior rail, and attached to it by nails or iron pins countersunk in it. The wheels of the carriages ran upon this iron rail, which formed a more durable surface than that of the wood. In the United States of America, railways of this construction are still in occasional use. They are recommended in that country by the abundance and cheapness of timber and the comparative high cost of iron. Such a road is tolerably efficient where the traffic is light and slow, and can therefore be resorted to in localities and circumstances in which an adequate return could not be obtained for the capital necessary for the construction of the more perfect modern railway. In the construction of these timber railways in America many other improvements have been introduced, more especially in the substructure of the road. In laying out the roadway for the reception of the rails, two parallel trenches are cut along the line of way corresponding to the distance between the rails, and transverse trenches at right angles to these are cut to receive the sleepers: these trenches are respectively bottomed with a ballasting of broken stone, on which the rails and cross sleepers rest. This basis answers the double purpose of a firm and durable support for the road and an effectual means of drainage. The scantling of the timbers used for the rails is usually six inches in width by ten inches in depth: they are attached to the sleepers, so as to be at once kept from springing from them and from altering their gauge, by the following means: A notch is cut in the sleeper corresponding to the size and form of the rail, and the rail, at the place where it is let into the sleeper, is formed with a vertical surface on the outside, and a levelled surface on the inside, increasing in width downwards. When let into the notch of the sleeper, the levelled part of the rail is forced into the corresponding cavity of the notch by a wedge driven between the outside edge of the rail and the outer surface of the notch.

The Plate Railway or Tramway.—In the progress of improvement, the timber railway above described was succeeded by the iron-plate railway, or tramway, in which the wheels —which were without flanges—ran on cast-iron plates formed with a ledge on the outer edge of each track to prevent the wheels from running off; and this species of road was for a long period almost exclusively used in the coal districts, and in public works generally, and is still employed to a considerable extent, especially in the railways which are carried through the workings of mines, and on which the produce of the mine is conducted in waggons, being pushed by men or drawn by horses to the foot of the shaft.

These tramways were for a long period constructed exclusively of cast iron; but, when improved methods of rolling malleable iron were contrived, they were formed by rolling.

Edge Railways.—Within twenty years after the first introduction of tramways of iron, the form of rail called the *edge rail* was brought into use. This rail is constructed in the form of a bar of iron, the width of which is considerably less than its depth, placed, as the name implies, with its narrow edge presented upwards. Owing to its depth being much greater than its width, its power, in proportion to its weight, to resist vertical pressure is very considerable. The wheels are retained on rails of this description by flanges projecting from the inside of their tires. These flanges, at the point where the wheels rest on the rails, descend below the rails; and the wheel cannot pass off the rail towards the outer side, unless the flange rolls over the rail.

For a long period after their first adoption, edge railways were confined to the mining districts, and more particularly to the collieries, where they were used for the transport of the products of the mines to the places of shipment; but this species of road acquired vastly increased importance when passengers and goods came to be transported on it by locomotive engines, which took place first on the Stockton and Darlington Railway in 1825, but more prominently between Liverpool and Manchester in the year 1830. Since that time, the construction of railways adapted for general traffic,

at a speed which would have been formerly thought impossible, has been carried to a great extent in all parts of the world.

Statistics of Railways.—It is now almost useless to collect the statistics of railroads, because in most countries the figures which are correct this day may be totally unfit to give the relative number of lines, and their lengths opened, a few months hence. Thus the Indian railways opened in May 1865 extended to a length of 3,186 miles, but it was calculated that they would extend at the end of that year to 4,917 miles. The following table, extracted from Perdonnet's *Traité Élémentaire des Chemins de Fer*, ed. 1866, will enable the reader to form some idea of the degree in which the various nations of Europe have availed themselves of the new means of locomotion.

Country	Length in Kilomètres opened	Length in Kilomètres granted	Length per Myriamètre square opened	Length per Myriamètre square granted	Length per Million of Inhabitants opened	Length per Million of Inhabitants granted
France, to 1861 .	9,441	15,025	1·9	2·8	268·0	419·0
Germany . .	13,728	"	1·15	"	180·5	"
Switzerland . .	1,051	1,500	3·5	5·1	457·9	625·0
Spain . . .	2,090	4,245	0·5	0·9	154·4	300·8
England . .	11,012	14,250	7·7	10·8	640·0	907·5
Scotland . .	2,203	3,075	2·9	3·9	150·0	1080·7
Ireland . .	1,947	3,319	2·4	4·4	299·5	510·0
Belgium . .	1,714	"	5·8	"	375·0	"

Within the limits of the present article, it would not be possible to trace, in the order of time, the succession of improvements by which the present methods of laying out and constructing railways for the swift transport of passengers by steam power have been established. When the Liverpool and Manchester line was first brought into operation, little, comparatively, was understood of the capabilities of such means of intercommunication; and that line may be regarded as an experimental railway, the results of which have supplied the data on which others have since been constructed and worked. The form, strength, and weight of the rails; the mode of fixing them on the road; the weight, power, and proportions of the engines; the form, strength, and weight of the carriages and waggons; the magnitudes of the trains, and the speed of transport, have all been subject to change from year to year, and almost from month to month, since the opening of that line in 1830 to the present time. We shall not, therefore, attempt to trace these improvements; but shall briefly explain the formation and construction of railways, according to the methods and principles at present generally received.

Gauge of Railways.—The gauge, or the distance between the rails, on which depends the distance between the wheels of the carriages and engines, and to a certain extent their structure, has frequently been a subject of much discussion. It is now generally admitted that all railways constructed in the same country ought to have the same gauge; and though it is not contended that the gauge now in use is the best that could possibly have been adopted, yet that, extensive lines of road having been constructed with that gauge, the disadvantages attending a departure from it will be greater than any counterbalancing advantages that could attend any other magnitude of gauge.

In the colliery railways in the north of England, the rails had been laid at 4 feet 8½ inches asunder; and on the Liverpool and Manchester Railway, the first line intended for general traffic was laid down by Mr. Stephenson with the same gauge. The lines of railway subsequently projected, extending from Liverpool and Manchester to Birmingham (and thence to London), to Preston, Wigan, Bolton, Leeds, and other places, were laid down with the same gauge, since the carriages and engines would necessarily have to pass from one to the other. But when railways began to be constructed in Belgium and other parts of the Continent, where the same reason for uniformity of gauge did not prevail, the same gauge nevertheless was adopted. The first conspicuous departure from this uniformity took place on the Great Western Railway, extending from London to Bristol, which was laid down with a gauge of 7 feet; and the Eastern Counties Railway next adopted a gauge of 5 feet. The latter line (now known as the Great Eastern) has since been reduced to the 4 feet 8½ gauge, and the same gauge has been laid down (in addition to the 7 feet gauge) on a considerable part of the Great Western system.

The gauge of a railway can be regarded as nothing more than its linear modulus, or the index to its general scale. There is nothing per se to give one gauge a preference over another; but, as the magnitude of the gauge determines the general magnitude and scale of the railway, and of everything connected with the railway, including waggons, carriages, and engines, bridges, viaducts, tunnels, cuttings, &c., and, in short, all the works, whether of a movable and perishable or fixed and permanent nature, it is a matter of the greatest

importance that it should be determined with a just regard to the traffic of the line.

The *battle of the gauges* may be explained on this ground, for there can be no doubt that the 4 ft. 8½ in. gauge was adopted by accident; but when once adopted, it was found to be more convenient to execute the rest of the railway system of the same dimensions. The facility afforded for intercommunication upon the uniform gauge, the economy resulting from the small gauge (which is a great element in the commercial results attending a railway), the greater ease of working, all give the narrow gauge advantages not compensated for by any perceptible amount of speed or convenience in travelling upon the broad gauge. The reader is referred, for an account of the struggle that took place on the subject of the gauges, to the pamphlet by Wyndham Harding on the question; to the *Report of the Gauge Commissioners*; to the *Life of Robert Stephenson*, vol. ii. ch. i., by Professor Pole, in which the arguments for and against the broad and narrow gauges are carefully stated. The result of the argument has shown that it is not worth while, particularly in a poor district, or in districts which do not contain the elements of an active circulation, to incur the expense of the broad gauge; and as the traffic of the lines of every country is destined, sooner or later, to intercommunicate in every direction, any break of gauge must always be attended with a considerable amount of inconvenience. Practically, the broad gauge has been abandoned, or at least the mixed gauge has been laid down on almost every line on which the broad gauge had been established.

Of the Formation and Construction of Railways.—Whatever be the moving power to be used for the transport of loads upon a railway, its force should be proportioned to the maximum resistance of such loads, and it should be capable of varying its energy to the same extent as that resistance is subject to variation. The great perfection which has been attained in the construction of the rails, and in the methods of fixing them in their position upon the road, is such, that the resistance offered to the tractive power by loads moved on a straight and level railway may be regarded as practically uniform, so that the moving power by which a load is transported at a given speed on a straight and level line of railway is subject to a resistance as unvaried and as uniform as any to which moving powers are usually submitted in any of the processes of art. But as the amount of resistance to the tractive power upon a straight and level railway is diminished by the perfection thus attained in the construction of the road, so, in the same degree, any resistance produced by a departure from a perfect level is more sensibly felt. Thus, if the resistance to the moving power on a straight and level railway, by a load moved at a given speed, be equal to the 250th part of the load, an acclivity which would rise at the rate of one foot in 250, or nearly at the rate of 20 perpendicular feet in a mile, would produce a resistance to the moving power, by reason of the ascent alone, equal to a 250th part of the load, and therefore equal to the resistance which the moving power would sustain on a level line. It follows, therefore, that, under such circumstances, in drawing a load up such an acclivity, the moving power would have to overcome twice the resistance opposed to it on a level; for the same causes which produce on a level a resistance amounting to the 250th part of the load also produce the same resistance in ascending the acclivity, in addition to which there would be an equal amount of resistance due to the ascent. If, therefore, under such circumstances, the moving power were required to draw the load up the acclivity at the same speed as that at which it drew it on the level, the machine exerting that power must be endowed with properties in virtue of which it becomes capable of varying its energy, without injury to its structure, in the proportion of two to one.

The power now employed almost universally to draw carriages upon railways is the locomotive engine, some of the wheels of which are rotated by being put into communication with the steam cylinders, and the friction of these wheels on the rails propels the train.

The tires of the locomotive wheels, and of the wheels of all the carriages, have usually a conical form given to them, becoming gradually smaller from the flange outwards; and, when a carriage rests straight upon the rails, the distance between the flanges of the wheels being less than the distance between the rails, a small space is left between the flanges and the rails, to allow some play to the flanges without letting them strike the rails. When the carriage comes to a curve, the flange of the outer wheel comes into contact with the outer rail, and the whole play of the flanges is given to the space between the flange of the inner wheel and the inner rail. In consequence of the conical form of the tires of the wheels, the outer wheels, in this case, rest upon a thicker part of the cone than the inner, and the actual diameter on which they revolve is consequently greater than that on which the inner wheels revolve. This effect has been generally regarded as an expedient sufficient to enable railway carriages to run round curves of a certain limited radius; but in some of the large continental locomotives other expedients are sometimes employed.

The pressure of the flange on the rail being the principal means of turning a railway carriage round a curve, and such pressure being attended by friction, and therefore by increased resistance to the moving power, curves as well as acclivities are a cause of resistance, and this resistance will be great in proportion to the rapidity of the curve or the shortness of its radius. But independently of this effect of curves, a more serious objection to curves of which the radius is under a certain limit of magnitude arises from the liability of the carriages to run off, by the flange encountering

any obstacle or inequality which would cause it to pass over the rails. This tendency is increased if there be a declivity as well as a curve, and if at the same time the train is travelling at a high rate of speed.

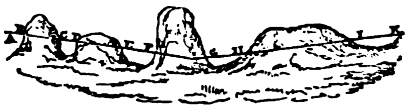
Curves on Railways.—With a view to insure the public safety, the legislature has generally required that no curve shall be allowed upon a main line with a less radius than one mile: the exceptions to this are where one railway passes into another, and at the termini, or the entrance of dépôts or stations. In such situations the trains must slacken their speed, and therefore a sharp curve is attended with less danger. It has appeared, however, that these restrictions upon the radii of curves have been more stringent than safety requires. In a course of experiments made by Dr. Lardner, it was established that curves of a mile radius produce no sensible increase of resistance at the usual speed of railway trains, and therefore curves of considerably less radius may be traversed at that speed without danger. We may here state, that on the Newcastle and Carlisle Railway there are many curves in the main line with radii under half a mile, which are traversed at the usual speed with perfect safety.

The *section* of a railway is limited by those circumstances which govern its acclivities, already explained, and which are equally related to the amount of resistance on level rails, and to the practical limits of the variation of the moving power. The *plan*, on the other hand, is limited by the necessity of effecting every change of direction of the line by curves of which the radius shall have such a magnitude as to exclude all danger of the carriages running off the line. In the laying out of a railway, therefore, limitations of its section and plan must be kept constantly in view.

Since the natural surface of a country is rarely adapted to the conditions which have been thus shown to be necessary to the formation of a railway, an artificial surface must generally be formed by raising some and lowering other parts of the country through which the railway is to pass. The expedients by which this is accomplished are attended with more or less difficulty and expense, and the skill of the engineer is eminently required in the selection of such a course for a proposed line of railway as will be attended with the least expensive construction, due regard being had to the permanent expense of working and maintaining it.

When a railway is proposed to be constructed between two points, which are called its *termini*, the engineer makes himself generally acquainted with the country between these termini, and selects that course for the line which, with least deviation from a straight line joining the proposed termini, will afford the greatest facilities for the formation of the artificial surface of the railway, limited as it must be in respect to its acclivities, and to the curves by which its various changes of direction are effected. This is first accomplished by an *eye survey* or general *reconnaissance* of the country. An instrumental survey is afterwards made along the direction which has been selected for the line, and a nearly accurate profile of the country from terminus to terminus, in the proposed direction, is obtained. This being accomplished and reduced to a drawing, as represented in fig. 1, a line A B C D E F G H I K is drawn, regulated by the degrees of inclination which have been decided to be the best practical limits of the acclivities. This line will, as

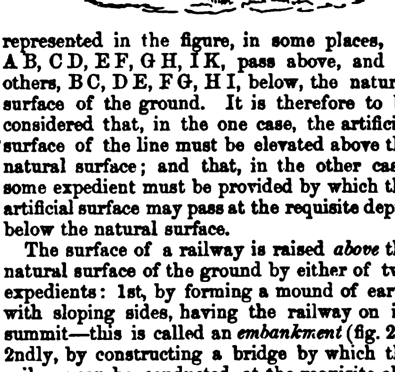
Fig. 1.



represented in the figure, in some places, as A B, C D, E F, G H, I K, pass above, and in others, B C, D E, F G, H I, below, the natural surface of the ground. It is therefore to be considered that, in the one case, the artificial surface of the line must be elevated above the natural surface; and that, in the other case, some expedient must be provided by which the artificial surface may pass at the requisite depth below the natural surface.

The surface of a railway is raised *above* the natural surface of the ground by either of two expedients: 1st, by forming a mound of earth with sloping sides, having the railway on its summit—this is called an *embankment* (fig. 2); 2ndly, by constructing a bridge by which the railway can be conducted, at the requisite elevation, above the natural surface of the ground in the same manner as a road is constructed over a river—such a bridge is called a *viaduct*. [VIADUCT.] Such structures are formed either

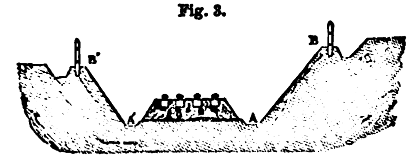
Fig. 2.



of masonry or of iron; but in countries such as the United States and Russia, where timber is abundant, cheap viaducts of carpentry are frequently used.

The surface of a railway is conducted *below* the natural surface of the ground by either of two expedients: 1st, by forming an excavation,

Fig. 3.



or artificial valley, with sloping sides, along the bottom of which the railway is constructed

—such an excavation is called a *cutting* (fig. 3); 2ndly, by undermining the ground and constructing a subterranean archway or vault of sufficient magnitude, the roof of which is usually lined with masonry, and along the bottom of which the railway is conducted—such an archway is called a *tunnel*. [TUNNEL.]

In laying out a railway, the disposition of its cuttings and embankments must be kept in view. In general, the material by which the embankments are formed is obtained from the cuttings; and, with a view to the saving of expense, the engineer so arranges his section that the quantity of stuff required for the formation of embankments shall be as nearly as possible equal to that supplied by the cuttings. If there be an excess of stuff from the cuttings, ground must be obtained in some position near the cuttings whereon it can be thrown. This is technically called *putting it to spoil.*

If, on the other hand, there be an excess of embankment, then the stuff necessary for the formation of such embankment must be obtained from some excavation made near the embankment expressly to supply the stuff for the embankment. This is called *side cutting.*

The distance along which the stuff obtained from a cutting is carried before it is laid down to form the embankment is called *the lead*; and the quantity of labour necessary to form an embankment out of an adjacent cutting is determined by the number of cubic yards of stuff necessary to form the embankment multiplied by the average *lead*, or the mean distance to which such stuff has to be carried.

Where a very low and long embankment occurs, it may happen that the *lead* is so long that the expense of forming the embankment from the nearest cutting would be greater than the expense of putting the cutting *to spoil*, and of forming the embankment from *side cutting*. These are questions which are determined in each individual case with reference to the price of land and labour.

When the elevation above the natural surface of the ground at which the railway must be carried is so great as to render an embankment impracticable, or attended with a disproportionate expense, a viaduct is resorted to; and, on the other hand, when the excavation necessary to give an open cutting would be productive of objectionable expense, then the railway is conducted under the ground through a tunnel.

The slopes A B, A′ B′, figs. 2, 3, forming the sides of embankments and cuttings, depend on the nature of the soil or strata through which the cuttings are made, and of which the embankments are formed. In general, every material has a certain angle at which it will rest, all more steep angles causing it to slip or fall; this angle is called, in mechanics, the *angle of repose*. In the strata through which railway cuttings are made, and from which embankments are usually formed, the slopes of the sides are rarely less than 1½ foot horizontal to 1 foot vertical, and they vary between that and 2 feet horizontal to one foot vertical. When the material is gravel, sand, loose chalk, or gravelly clay, a slope of 1½ to 1 is generally found sufficient; but with certain descriptions of clay, such as that called the London clay, a more gradual slope must be allowed. With such material, the slopes are constructed at 1½ or 2 horizontal to 1 vertical; but in general it is better, even at increased expense of earthwork, to allow a sufficient slope in the commencement, and thereby avoid the continual expense attending *slips*, as the gradual decadence of the sides of cuttings and embankments is called.

The face of slopes, both of cuttings and embankments, should be covered with soil and sown with grass seeds, so as to produce a turf, which gives a further security against *slips*. They may be also, especially the slopes of embankments, planted with shrubs; care being taken, however, not to obstruct the ventilation of the road.

When the stratum through which a cutting is required to be made is rock or hard stratified chalk, it will stand with perpendicular sides; and, in such cases, cuttings of great depths may be made at a trifling sacrifice of land. The Olive Mount cutting on the Liverpool and Manchester Railway is, at the deepest parts, above 100 perpendicular feet from the natural level of the surface to the level of the rails; and cuttings of still greater depth and much greater extent, through stratified chalk, are executed on the Brighton Railway, of which the sides are perpendicular.

In most cases, however, where cuttings attain to these extraordinary depths, tunnels would be less expensive. It sometimes happens that the material of the cutting is required for an adjacent embankment; and, under such circumstances, if the sides of the cutting can be perpendicular, and the sacrifice of land small, it may be preferable to tunnelling. The materials from the Olive Mount cutting above mentioned were required for the formation of the Broad Green embankment adjacent to it.

The physical peculiarities of the ground over which many of our railways have been carried, have caused formidable difficulties in their construction. Chat Moss, on the Liverpool and Manchester line, was 4½ miles across when the railway was carried over it, and from 20 to 40 feet deep. Cattle could not stand upon it, and a piece of iron would sink into it by its mere weight. To form an embankment of 277,000 yards, 670,000 yards of material had to be thrown into the bog. In the Haslington cutting, on the East Lancashire line, half a million yards of peat, sand, and gravel, had to be excavated from a bog hole, and two trains carrying earth for three months were unable to obtain a foundation. Large stones were finally thrown in, which pressed the peat aside, and enabled the line to be carried across. The Ogden viaduct, which is carried over a quicksand 50 feet deep, required 1,500 cubic yards of earthwork to

be thrown in daily for many weeks to obtain a foundation. At Ashton, where a fifty-feet embankment had to be raised, the ground sank with the weight of the earth, which disappeared as fast as it was deposited, and at length the surface of the surrounding fields burst upward with the pressure. On the Leeds and Bradford, Durham and Sunderland, Midland and many other railways, the line has been carried over bogs and swamps, by which large quantities of material were swallowed up before any visible progress could be made. At the Ambergate cutting the occurrence of a seam of shale, rising at an acclivity of 6 to 1, caused the whole side of a hill to slip down, and involved the necessity of removing 500,000 yards of earth. Then in carrying tunnels through some hills the quantity of water to be pumped out presents a serious impediment. In forming the Box tunnel on the Great Western line, 32,000 hogsheads of water had to be raised daily for many months. In the Kilsby tunnel, on the North-Western line, 2,000 gallons of water had to be raised per minute for eight months. In forming the Woodhead tunnel of the Sheffield and Manchester line, eight million tons of water were raised in five years. On the Dundalk and Enniskillen line, an embankment twenty feet high sank in a concealed bog and stopped a river, the country being flooded in consequence. Sometimes embankments have been made of fuller's earth, which melts down with the rain. The introduction of iron pyrites has sometimes caused embankments to give forth smoke and flame, and to burn the sleepers; and if pyrites come into contact with chalk, crystals of selenite are formed, which disintegrate the clay, alter its bulk, and render it treacherous. These facts illustrate the importance of a minute examination of the ground over which any line of railway has to be carried, in order that such sources of expense and failure may as far as possible be avoided.

The quantity of earthwork per mile of railway varies, of course, very much upon different lines; but taking upwards of 8,000 miles of English railway, Mr. Robert Stephenson estimated that the average earthwork per mile was 68,300 cubic yards. On the London and Birmingham, London and South-Western, London and Brighton, and North Midland, it is more than twice this amount. The London and Birmingham line had 12,081,116 yards of excavation, and 10,698,315 yards of embankment in the original estimate, or together 202,934 cubic yards per mile. The heaviest cutting on the line is at Tring, which is 2½ miles long, and averages 40 feet deep. The New Cross cutting of the South-Eastern line is two miles long, and for some distance is from 75 to 80 feet deep. The Box cutting of the Great Western Railway is 2½ miles long, and averages 30 feet deep. The Brentwood cutting of the Great Eastern Railway is upwards of a mile long, and 60 feet deep; and the Olive Mount cutting on the Liverpool and Manchester Railway is two miles long, and 100 feet deep. Nearly all the English lines are formed with a double track, and with a gauge of 4 feet 8½ inches between the inner edges of the rails, the Great Western alone and its branches being formed with a gauge of 7 feet, but on a large part of this line a third rail has now been laid down to enable narrow-gauge engines and carriages to travel over it.

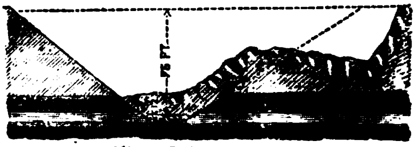
In English railways the standard width of the *formation level*, as it is termed, or the width of the ground between the ditches, is 32 feet, and the ditches are each 3 feet wide at top, 1 foot wide at bottom, and 1 foot deep. The width of the ballast at the top is 23 feet 5 inches, and at the bottom 27 feet 5 inches, and it is 2 feet thick. The wooden cross sleepers embedded in it are 9 feet long. On the outside of each ditch there is a breadth or terrace of 18 inches wide; and if the railway is in a cutting, the bottom of the slope springs from the outer edge of the terrace, rising at a slope of 2 to 1, so that the total width of the bottom of the cutting is 41 feet. In the French railways the dimensions are nearly but not quite the same. The width of the formation level is 30 feet 10 inches, and the ditches are each 4 feet 11 inches wide at the top, 19⅝ inches wide at the bottom, and 19⅝ inches deep. The breadth of the shelf or terrace at the outer side of each ditch is 19⅝ inches or 50 centimètres, and the total width of the bottom of the cutting is 43 feet 11½ inches. The width of the track, measuring from the centre of each rail, is 150 centimètres or 59 inches, and the width of the ballast at bottom is 27 feet 6¾ inches; at top, 22 feet 11½ inches; and the thickness of the ballast 19⅝ inches. The sleepers are a little shorter than on the English lines. The side drains on all lines are made much broader and deeper than the foregoing in certain cases, where large volumes of water have to be carried off.

Drainage.—One of the conditions most powerfully affecting the security, durability, and efficiency of a railway is the efficiency of its drainage. The history of all failures in earthworks shows that in almost all cases they arise from unskilful or inadequate drainage; and the expense of maintenance on every line will, other things being the same, vary very nearly in the proportion in which its drainage is good or otherwise. Drainage may be divided into two main parts; drainage of the roadway and drainage of the slopes. Water lying or running on the surface soaks and softens the roadway, washes away the earth, and chokes the ditches. The roadway, when thus saturated with water, loses its firmness, and the ballast sinks and disarranges the track, adding seriously to the jolting of the train, to the power necessary to propel it, and to the wear and tear both of the train and track. Clay is converted by water into mud, and swells in bulk; and when it is afterwards

dried by the sun it forms cracks which give ready entrance to subsequent rain, and increase the disintegration caused by frost. The subsidence of the ballast from the ends of the sleepers so induced leaves the rails without uniform and regular support, and the rails are thus strained, the fastenings and chairs broken, and the deflection of the rails, causing the locomotive to be constantly going uphill, sensibly increases the consumption of fuel. The expense incident to the constant rectification of these evils is much greater than that which would be necessary to drain the line thoroughly at once; and it is a primary condition in the execution of all railways upon which rain ever falls, that they shall be thoroughly drained. The surface drainage must provide for the immediate removal of water falling upon the earthwork and slopes at a depth of at least three feet from the surface of the rails, and the drains on slopes must be formed with such a gradual declivity as to prevent the velocity of the running water from tearing up the soil. The side drains in some places are widened from three to thirteen feet and deepened to six feet, and the ditches should be cut as straight as possible, and equally distant from the roadway in all parts. Care should also be taken that the ditches shall empty themselves, and not become receptacles for stagnant water. Culverts are circular or barrel drains built of brick or stone across the railway at a sufficient depth to afford communication between the ditches. They are built with cement, which is allowed to be well consolidated before they are covered in. On the London and North-Western Railway, cross underground drains, of circular perforated tiles, are used. In cuttings the track generally slopes to each end, both to diminish the quantity of cutting and to give free outlet for the water, and if the slope is steep, the side ditches are usually lined with brick or stone. In some of the deep chalk cuttings, the side drains are formed of large bricks, and run the whole length of the cutting underground, with cesspools at convenient distances. These underground drains are often made of semicircular tiles, perforated and resting on flat tiles twelve inches square. In wet cuttings and in tunnels, covered longitudinal drains are made along the middle of the line. Some of these drains are oval, of three feet vertical diameter and two feet horizontal, and the bottom of the drain is set from four to five feet below the surface of the ballast. In the Blisworth cutting the covered drain is an arch thirty inches deep and twenty-one inches wide at the springing, and the bottom is thirty-nine inches below the surface of the ballast. In railway works as well as in agriculture, experience shows that sub-drainage is both cheaper and more efficient than the system of open ditches, as a covered drain sunk three feet below the surface will carry off more water than an open ditch of ten times the capacity. The importance of thorough drainage is shown by the fact, known to every engineer, that the wear and disarrangement of track is found to be from one-fourth to one-half less on moderately high embankments than it is in cuttings; this difference being wholly caused by the more effectual drainage realised in one case than in the other.

The drainage of the slopes is as important as the drainage of the roadway, since, unless such drainage is effectual, formidable slips will certainly occur in many kinds of soil, and the cutting may be choked up in consequence. Fig. 4 represents a slip which took place some years ago on the London and Brighton Railway. The original slope was two to one, and the depth of the cutting was from seventy-five to eighty feet. The upper clay abounded with soapy earths and mineral salts, which rendered it very pervious to water; and becoming completely saturated by the rain which fell in a wet season,

Fig. 4.

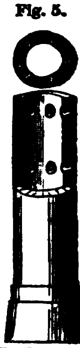


Slip on Brighton Railway.

it slipped forward on a more compact clay below and buried the rails to a depth of twelve feet. The line was stopped in consequence for three months, for not only had the fallen earth to be removed, but the sides of the cutting had to be cut back into benches, two on the one side and three on the other, these benches being in some places sixty-five feet wide, and the intervening slope was made two to one. In all, 250,000 cubic yards of earth had to be removed.

The method most generally adopted for preventing slips in treacherous ground consists in the excavation of vertical trenches at regular distances along the face of the slope and filling the excavation up with counterforts of gravel, for which footings are cut in the solid earth below. These counterforts, by their weight, friction, and porosity, are found to be effectual in preventing slips from taking place. Another method consists in sinking wells in the upper ground, so as to intercept the water before it reaches the face of the slope; while a third method, first recommended in the *Artizan* in 1843, and since carried out on some of the French lines, consists in cutting a vertical trench or drain from the top of the slope to the level of the rails beneath, and filling it with stones to constitute a drain from which the water may be led off to any convenient outlet. This mode is expensive. But another mode, also propounded in the *Artizan*, would be equally effectual and would cost less. It consists in cutting horizontal trenches of moderate depth along the face of the slope, the bottom of each of which would come at least as low as the top of the trench next

Fig. 5.



Perforated Drain Pipe.

beneath. These different trenches are to be filled with stone, and are to communicate at intervals with one another, so as in effect to constitute a drain extending through the whole depth of the embankment. Large slips are promoted by frost, which seals up the face of the cutting and causes the water to accumulate behind until its hydrostatic pressure forces out the face of the cutting. Probably a combination of the horizontal drains in steps, with vertical counterforts of gravel at some distance apart to connect the drains together, is the cheapest and most eligible expedient for draining the slopes of heavy cuttings. In cases where the amount of drainage to be accomplished is not great, the introduction of perforated tile pipes of the form shown in fig. 5 will probably suffice.

Ballast.—The ballast of a railway consists of porous materials laid on the surface of the ground in which the sleepers are embedded. These materials are either broken stone, gravel, burnt clay, cinders, sand, broken bricks, or small coal; but of these gravel with a natural mixture of clean sand is the best. The ballast, besides securing the sleepers and rails in their place, promotes by its porosity the thorough drainage of the line, resists the sinking of the sleepers, and enables them to be readily packed up, while it gives a proper amount of elasticity to the road, which is more conducive to durability than the plasticity of earth or the rigidity of rock. Very hard materials do not act well as ballast. Broken trap-rock becomes consolidated, by packing, into so inelastic a mass that the rails are soon battered out. When broken stone is employed as ballast, the pieces should go through a 2½-inch ring. Limestone binds too much for ballast, but gneiss rock and even sandstone answer very well. Slate is rapidly disintegrated in wet weather. Gravel, if too fine, will not drain well, and if too coarse, will not pack well. Burnt clay is used in alluvial districts where gravel is not to be had, and has been widely employed in the Indian railways. A ton of small coal will burn from 20 to 25 cubic yards of clay; and where coal or wood is cheap, this kind of ballast is as cheap as gravel if the latter has to be brought 6 or 8 miles. Of the 2 feet of thickness of ballast used on English lines, 1 foot is below the sleeper and 1 foot around and above it. Although on the French lines the standard depth of the ballast is 50 centimètres, the thickness is made 10 centimètres more, or 23½ inches in situations where the soil is bad. In America the railways are in general very imperfectly ballasted, and the cost of maintaining them is consequently very great. The expense of maintenance per mile run of the great English railways is found to be only about one-fourth of that of the great American lines; and if the latter could be made to work with equal economy, the saving, it is computed, would add 1·8 per cent. to the dividend. It is mainly in the difference in the earthworks, drainage, and ballasting, that the great difference in the cost of maintenance is to be found.

Sleepers.—In most of the English and foreign lines the rails rest in cast-iron chairs, which are spiked to cross sleepers of wood; but in the Great Western and a few other lines the rails rest upon longitudinal beams of wood, and in the American lines the bottom flange of the rail is for the most part spiked directly down upon the cross sleepers without the intervention of chairs. Stone blocks, which were generally used in the early railways for supporting the chairs, have now been discarded. But sleepers of cast iron have latterly been in many cases employed. These consist either of plates, or inverted pots like dish-covers, with holes on the upper side to permit packing, and connected by tie rods across the railway. In some cases the chair is cast on the top of the sleeper, and in other cases it is bolted on. In some instances rails have been employed formed with a wide and deeply immersed base, with the view of dispensing with sleepers altogether. But this species of railway has not yet attained any great success.

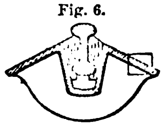
The sleepers commonly used on the English lines are larch trees of about ten inches diameter split through the middle; the flat side is laid upon the ballast, and the chair is fixed upon a flat seat notched out upon the convex side. Oak makes better sleepers than softer woods, but is too expensive for general purposes. It may, however, be put down in sharp curves and in other exceptional situations. The sleepers should be straight and of uniform size. They are usually laid at a distance of 3 feet from centre to centre, which gives about 2½ square feet of bearing surface for each running foot of track. In lines with a heavy traffic the sleepers are pitched at 2½ feet distance, thus giving 3 square feet of bearing for each running foot of track. In the American lines the sleepers are pitched at about the same distance as on the English lines or a little closer. It is found, by experiment, impracticable to use alternate wood sleepers and stone blocks, from the unequal nature of the support. But wooden blocks alternating with wooden sleepers have been tried in France, and have been found to answer well. The beams used on the longitudinal system for the support of the rails are ten inches square, and these beams are connected at every 6 feet by cross pieces of 6 by 4 inches.

The ordinary duration of sleepers laid down in their natural state is seven years. By creasoting their cost is increased about one-fourth, but their durability is more than doubled. Creasoting is accomplished by forcing coal oil into the timber by hydrostatic pressure, the timber being placed in a great cylindrical vessel of wrought or cast iron like a boiler, to enable it to be soaked and penetrated by the preservative liquid. The timber is laid on a truck, and run into this cylinder, from which the air is then exhausted after the movable end of the cylinder has been screwed on. This exhaustion is accomplished by an air pump worked by an engine of six or eight horse power. The preservative liquid is then allowed

to enter, and a vacuum of 27 or 28 inches of mercury is maintained within the cylinder for half an hour, at the end of which time the liquid is forced in with a pressure of 130 lbs. per square inch. The pressure is maintained for six or seven hours, at the end of which time the process is complete. Coal tar contains ammonia, which rots wood, but is expelled by boiling, and the boiled tar is called *coal oil.* This usually contains from 10 to 15 per cent. of creasote. The quantity of creasote present in such oil may be determined by shaking up with it in a bottle about 10 per cent. of a strong caustic alkaline solution; the liquid will settle into three layers, of which the lowest is caustic alkali, the middle creasote, and the upper (which is by much the largest) bituminous oil.

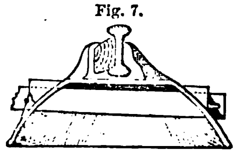
The forms of cast-iron sleeper which have been introduced on different lines are very various. Fig. 6 represents Samuel's cast-iron and timber-cushioned sleeper, which is 42 inches long, 16 inches wide, weighs 132 lbs., and gives a bearing of 672 square inches. De Bergue's cast-iron sleeper consists of a rectangular plate 20 inches by 14 rounded at the corners and strengthened by feathers. It weighs from 46 to 56 lbs. and gives nearly two square feet of bearing. Greaves' spheroidal or pot sleeper is shown in fig. 7. This sleeper has been much used on the Indian lines and also on other lines abroad. The packing is accomplished through holes left near the crown for that purpose. In all these sleepers there are tie rods for connecting them together across the line so as to keep the rails in gauge.

Fig. 6.



Samuel's cast-iron Sleeper.

Fig. 7.

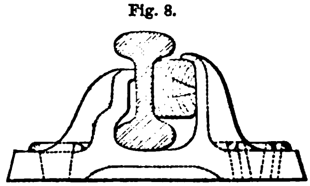


Greaves' Pot Sleeper.

Rails.—In the early railways much attention was paid to the quality of the iron of which the rails were composed; but subsequently this condition was relaxed, and a very inferior quality of iron was for many years admitted. More recently, however, the quality of the iron used in the manufacture of rails has been improved, and steel rails have also been tested, and are likely to obtain a wide introduction. In 1856 rails of 85 to 100 lbs. per yard were considered by English engineers to be the best. But in the succeeding decennium lighter rails, more thoroughly shingled and better worked in the rolling, were found to be preferable. On the Great Eastern line, the 95 lb. rails were found to wear more and make a worse road than the 75 lb. rails, and on the London and North-Western line the 82 lb. rails were found to be worse than the 56 lb. The Grand Junction line, laid with 62 lb. rails in 1837, remained in good order without the necessity of removing any of the rails till 1849, when a few 80 lb. rails were put down, and these showed more wear in twelve months than the old rails exhibited after enduring the traffic of twelve years.

The double-headed form of rail is usually now employed in England and most other countries, one object of this form being to allow the rail, when worn on the top, to be turned upside down. But sometimes the bottom is so much indented by the chair as to prevent this. In this form of rail a chair is required for every sleeper, and the rail is usually fixed in the cast-iron chair by a wooden key driven in at the side, the wood (before being cut into lengths) being compressed by hydrostatic pressure or otherwise to prevent subsequent shrinking. The common depth of rail is five inches. It is found that a 50 lb. rail 3⅝ inches deep and with a 3 feet bearing deflects sufficiently under a fixed load of five tons to be equivalent to a gradient of 25 feet in the mile; and it has further been found that, while gravity has to be overcome by ascending the hills, no return of it is got back in descending the hollows. With a moving load the deflection would be doubled. The deflection of the rails is as the cube of the distance between the supports; and if some of the sleepers sink, the deflection and consequently the resistance of the line will increase at a very rapid rate. This accounts for the great additional tractive power required on rough lines which have fallen into disrepair.

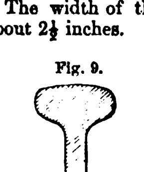
Fig. 8.



Standard English Rail and Chair.

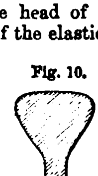
The width of the head of modern rails is about 2½ inches. If the elasticity of the metal be supposed to be such that a sheet of paper could be got only within half an inch of the bearing point of a five-foot driving wheel, the wheel would from this amount of yielding be constantly ascending a gradient of 45 feet per mile. Fig. 8 is a section of a standard English rail and chair, and figs. 9 to 18 are cross sections of the most prevalent forms of rails, both English and foreign.

Fig. 9.



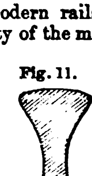
Spanish, 74 lbs.

Fig. 10.



Marseilles, 66 lbs.

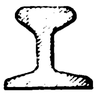
Fig. 11.



Strasbourg, 72 lbs.

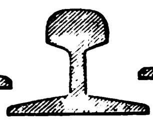
Fig. 19 exhibits Barlow's form of rail, which has been laid down to some extent, and which is employed without chairs, the bottom part

Fig. 12.



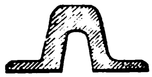
American.

Fig. 13.



Great Western.

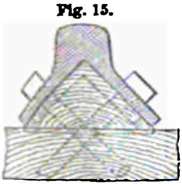
Fig. 14.



Great Western.

being immersed in the ballast. But it has been found to be unstable, difficult to pack and to drain from a propensity to suck up water beneath the head, and the head has been found liable to split. Lengths of this rail of five or six miles have been riveted together without any inconvenience having been experienced from expansion.

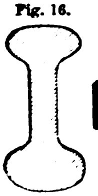
Fig. 15.



Seaton's Rail, Great Western.

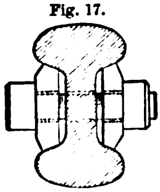
The length of rails is usually from 18 to 21 feet. Their durability depends chiefly on the quality of the iron employed; and heavy rails are less durable than light. Rails are tested by allowing a weight to fall upon one rail in (say) every hundred. In the rails of the Royal Swedish Railway a ram weighing two tons was

Fig. 16.



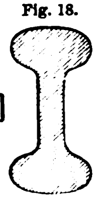
London and South-Western, 80 lbs.

Fig. 17.



Leicester and Hitchin, 92 lbs.

Fig. 18.

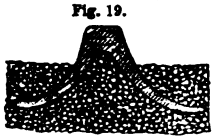


London and North-Western, 85 lbs.

allowed to fall from a height of twelve feet on a rail laid on supports four feet apart, but this test was unusually severe. In some cases the heads of the rails have been made of a superior iron, or of steel, by welding on iron of a superior quality or steel. But there is always the risk that the weld may not be sound and secure. Sometimes the tops of the rails are case-hardened. But the cheapening of steel by the Bessemer process is extending the production of rails made of steel throughout.

Joints of Rails.—The ends of the rails are cut off square, and (to allow of their expansion) a minute distance is left between them at common temperatures. At a temperature of 100° the ends are placed in contact; at a temperature of 0 they are laid at a distance of ·163 from one another. On the English lines the rails of each

Fig. 19.



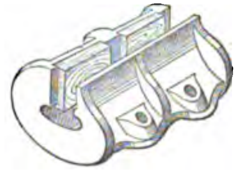
Barlow's Rail.

track break joint with one another; but on the American lines both joints are usually on the same sleeper. For many years the only fastening which united the ends of the rails was obtained by placing the ends in a long chair and keying them up together. But it is now usual not to place the contiguous ends in a chair at all, but to attach them together by means of plates bolted through the sides, the bolt holes being made slightly oval to permit expansion. It is reckoned that a variation in the temperature of iron of 10° or 12° produces a force of expansion equal to one ton per square inch of section; and in America, where the alternation of temperature is great, it has been found in some cases that unless space for expansion has been allowed, and the rails have been laid in cold weather with close joints, the track has in some places been raised vertically a foot, and has been bent out sideways two or three feet by the expansion of the rails. Sometimes on steep gradients the rails are found to have a tendency to creep to the lower end.

The joint chair usual on English lines weighs from 26 to 40 lbs. and the intermediate chair weighs from 18 to 26 lbs. Ramsbottom's chair is made of wrought iron, and is formed by rolling out a channel of iron with flanges on each side, and this is afterwards cast off in short lengths, each of which forms a chair. The sides of the chair are somewhat inclined, and pieces of iron or fishes are fitted on each side of the rail, making the total thickness equal to the width of the head; the rail with these fishes is then set in the chair, the bottom of which, however, it does not touch, and it jams itself tight by the weight rolling over it. In some cases the side wedges used to secure the rails in the chairs are of iron instead of wood, and sometimes, when of iron, they are made hollow to give a certain elasticity. Fig. 20 represents Parsons' wedge chair, which is formed with recesses, into which are introduced short pieces of wood with their grain directed against the rail, an iron wedge being driven in between the rail and the chair. One side of the wedge presses on the wood under this arrangement, and that side is barbed up with a few projections like those of a file, to prevent the key from working back.

Fig. 21 is a side view and cross section of a fish joint. The weight of the fishes is 22 lbs., and of the bolts, nuts, and washers $2\frac{1}{2}$ lbs. The bolts of fish joints are usually $\frac{7}{8}$ of an inch diameter. Many plans have been proposed to prevent the bolts and nuts from turning round and becoming loose; but the best appears to be to nick slightly the thread of the bolt with a chisel after it has been screwed up, as this will prevent it from unscrewing of its own accord

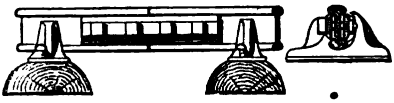
Fig. 20.



Parsons' Chair.

from vibration, and yet will not prevent it from being screwed up or unscrewed by a com-

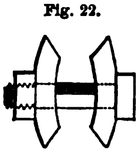
Fig. 21.



Adams' and Richardson's Fish Joint.

mon wrench, which will shear off the slight burr in the screw. Fig. 22 is a representation of Wild's grooved fish, of which the sides are grooved to hold the head of the bolt, and to catch the nut when it turns square with the groove. The weight of this pair of fishes is 22 lbs., and the weight of the four bolts and nuts is 4½ lbs.

Fig. 22.



Wild's Grooved Fish.

Switches.—In order to deflect a train from one line of rails on to another, movable rails called *switches* are employed, which at one end are fixed to a centre, while the other end, which is tapered to a point, is moved against the side of the rail by a horizontal rod and handle, to which a heavy weight is attached to bring back the switch to its normal position as soon as the handle is released. Switches are either single or double, the first being made with one movable rail, and the second with two. Double switches are usually employed for sidings, on the main line as they throw the rails less out of gauge and less disturb the continuity of the line. They are usually made out of the rails in common use upon the line. The subordinate features of their construction are very various, one main object sought to be attained being to gain sufficient strength in the point to prevent it from being crushed before the full breadth of the line is reached. In Wild's switch this end is attained by so tapering the point or tongue that its end is housed beneath the top of the fixed rail when shut against it.

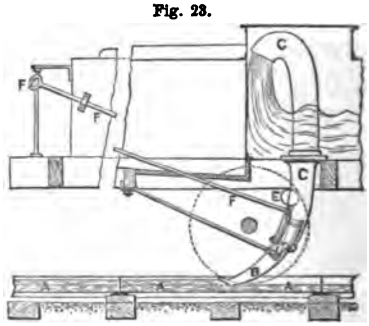
Turntables.—These are expedients, chiefly employed at termini, for transferring the engines and carriages from one line to another. A platform or table supported round the edge by rollers is made to turn upon a central pivot. The carriage or locomotive being pushed on to this platform, the platform is turned round until the wheels are brought opposite to the other set of rails upon which the carriage has to be delivered. A catch, then allowed to drop, fixes the table, and the vehicle is then delivered upon the other set of rails. The indications to be fulfilled in the construction of turntables are strength, steadiness under a passing load, small friction in turning, and as far as possible independence of foundations.

Traversers.—Instead of turntables traversers are sometimes used to transfer carriages from one line to another. A platform with rails laid upon it is made to move sideways on wheels beneath, and the carriage being run upon this platform is carried sideways until it comes opposite the other line. This plan, however, does not answer for transferring locomotives which have to be also turned round when set upon the other line.

Water Cranes.—To supply the locomotives with water, elevated tanks are erected along the line at suitable intervals, and a pipe with a swivelling arm like a crane is swung over the line, when the engine stops, to conduct the water from the tank into the tender. The construction of these swivelling pipes or water cranes is very various, and in some cases provision is made for heating them by a fire in the event of frost. Sometimes a roller pressed by a weight is made to act on an inclined plane on the side of the pipe, so as to swing back the pipe like a swing gate as soon as it is released, thus obviating the risk of leaving the crane standing across the line.

Supplying Water while running.—On the Chester and Holyhead Railway near Conway a long trough has been laid down between the rails, into which a scoop is dipped when the locomotive comes to that part, the water being thus lifted into the tender without stopping the engine. The form of this contrivance is shown by fig. 23, where A A is the trough, B the movable part or scoop of the pipe C, F is a

Fig. 23.



Feeding Tender while running.

handle by which the scoop is depressed, and E is a counterweight which brings the movable part of the pipe—and which swivels round a horizontal pin—back when the handle is released. The trough contains five inches of water, and the scoop dips two inches into it and scoops up that depth of water at speeds exceeding twenty miles an hour. But at lower speeds the water will not be delivered over into the tender. This contrivance effects a sensible saving of time in express trains, and it is found that the thin ice which can alone be formed in frosts during the intervals of passing trains does not interfere with its efficient action.

Resistance of Railway Trains.—In the early history of railways the resistance was considered to be directly as the speed. But it was subsequently shown by Dr. Lardner and others that it increased in a much more rapid ratio, and was in point of fact more nearly as the square

of the speed. More recently, however, it has been found that this rapid increase of the resistance takes place only on rough lines; and that on very smooth lines, when there is no side wind blowing, the resistance varies nearly as the simple speed.

Speed of Railway Trains.—The average speed of express trains on the London and North-Western Railway is, including stoppages, about 40 miles an hour; on the Great Northern, 39½ miles; on the South-Eastern, 37½; and on the South-Western, 35 miles an hour. Speeds of 60, 72, 78 and even 93 miles an hour have been attained for short distances. The London and North-Western runs a train over 82¾ miles in 1 hour 54 minutes, and the Great Western one from Paddington to Bristol, 117 miles, in two hours.

Consumption of Fuel per Mile.—The express trains on the London and South-Western Railway burn 17 lbs. of coal per mile, but on occasions have burnt as little as 14 lbs. The American express trains burn a cord of wood in from 20 to 30 miles. A cord of wood weighs 3,000 lbs., and 1¾ cord of wood is equal in heating power to a ton of bituminous coal.

Mountain Railways.—Railways have been carried over the Styrian Alps, and up the Ghauts in India, by employing powerful engines with many coupled wheels, and by constructing the line on a tolerably easy incline. They have been carried over parts of the Andes by employing stationary engines to pull up the trains by ropes; and more recently a line has been carried over Mont Cenis by forming the track with a deep central rail, on the opposite sides of which rollers are made to press by suitable mechanism, so as to grip the rail. By rotating these rollers by vertical spindles connected with an engine, the train is propelled up a very steep gradient at a low rate of speed. This appears to be the most suitable method yet introduced for surmounting steep inclines.

Railway, Atmospheric or Pneumatic. A species of railway in which the propelling power is the pressure of the atmosphere on one side of a piston or diaphragm and a partial vacuum on the other side. In one of the forms in which this principle was applied by Mr. Clegg, and which was tested some years ago on the West London Railway at Wormwood Scrubbs, and subsequently introduced on the Dalkey, Croydon, and South Devon lines, a large pipe was carried along the centre of each track, this pipe being partially exhausted by steam engines stationed at intervals along the line. A piston attached to the train travelled in this pipe, and being propelled forward by the air, which was allowed to press behind it, while a partial vacuum was maintained in front, the piston was carried forward, drawing the train with it. To enable the connection between the piston and the train to be maintained, a bent arm passed through a long slit on the top of the pipe. This slit was covered by a leather flap or valve extending the whole length of the line, the valve being made tight by tallow, which was soldered tight by a hot iron carried in the part of the train in the rear of the piston. Mr. Robert Stephenson, who reported upon this system in 1844, showed that it was both troublesome and wasteful, and was not likely to come into general use in competition with the locomotive, and it has since been removed from all the lines on which it had been introduced. The atmospheric system, however, or some modification of it, though not adapted for indiscriminate use as an economical system, seems likely to find special applications of importance, such as in ascending steep inclines, in working underground railways, and in conveying mails and merchandise through tubes. This last application has been carried out in London by the Pneumatic Despatch Company with success. But the power consumed relatively with the work done is very great. In August 1861 the experimental tube, which was subsequently put down between Eversholt Street and Euston Station for the transmission of the mails, was tested at Battersea, and it was found that, taking into account the pressure produced by the air and the distance traversed by the piston or carriage, and comparing the result with the indicated power of the engine employed to pump the air, only twenty per cent. of the engine power was utilised, while eighty per cent. was lost. On the line of tube between Euston and Holborn, similar results have been obtained. This tube is flat on the bottom and arched on the top, and is 4 feet broad and 4½ feet high. It is fitted with rails, on which a truck runs. The truck is made tight against the tube by an Indian rubber ring, so that it acts like a piston; and with a load on the truck of 10 tons, including the weight of the truck itself, a pressure of air of 4 ounces per square inch propelled the truck from Euston to Holborn, a distance of 1¾ miles, in 7 minutes. The pressure of air is obtained by a fan 22 feet in diameter, making 170 turns per minute, and the fan can be made either to suck or blow, or both; but the leakage is found to be greatest when the fan is made to blow, or to compress the air, and thus push the carriage on. The indicated power required to work the fan is found to be about 200 horses, and the efficacy is only 18 per cent., the loss being 82. This great loss may probably be reduced hereafter by the use of more suitable apparatus; and even with a large amount of loss the system appears to be suitable for especial purposes, where by any other known arrangement still greater evils would have to be encountered.

(Perdonnet, *Traité Élémentaire des Chemins de Fer*; Goschler, *Traité pratique de l'Entretien et de l'Exploitation de Chemins de Fer*; *Les Annales des Ponts et Chaussées, des Mines, &c.* passim; *Trans. of the Institution of Civil Engineers*; *Descriptive Catalogue of the Exhibition* of 1851 and of 1862; *Les Comptes-Rendus de la Société des Ingénieurs Civiles*, passim.)

Railways, Law of. Companies for the construction of railways are now provisionally registered under the Companies Act 1862 until

their Act of incorporation is obtained. Each particular railway Act is called the special Act, and incorporates in its provisions those of the Clauses Consolidation Acts (Companies, Lands, and Railways, 1845 and 1863), which respectively govern, as to all essentials, the constitution of railway companies and their powers; the rights of shareholders and others who invest in the capital needed to enable the directors to carry on the business of the company; and the powers of the company to take and purchase land for the purpose of constructing the railway and works connected therewith. The special Act declares the amount of capital, the limited liability of each member, who is not chargeable on account of any debt or demand due from the company beyond the extent of his share in the capital of the company not then paid up; the number of directors, the line of the intended railway, tolls, and so forth. The company being now constituted, two meetings of shareholders, called *ordinary* meetings, must be holden every year, as provided by the Companies Clauses Consolidation Act 1845; extraordinary meetings can be convened by the directors as they may think proper. The special Act always names the first directors; afterwards they are elected by the shareholders. The powers of directors are fixed by the general Acts above referred to (the most important power, in a legal point of view, is that of making contracts on behalf of the company); and the directors are personally indemnified for all losses &c. which they may incur in the execution of such powers. The company obtains permission and compulsory power to take, or injuriously affect land for the purpose of their railway. Compensation under 50*l.* may be assessed by two justices: in higher cases by arbitration; by the verdict of a jury, to be summoned by the sheriff on a warrant issued by the company; by a surveyor named by justices in certain cases, where the party fails to appear before the jury. The legal powers which enable the company to construct the railway and necessary works are defined in the Railway Clauses Consolidation Acts, and are very extensive, but subject to many legal restrictions as to the mode of construction. The Board of Trade has the authority of sanctioning, within certain limits, deviations from the works originally undertaken; and it has also certain special authorities to superintend the line and works of a railway after it is opened; to regulate other matters; and, finally, to authorise the abandonment of railways. Railway companies have always hitherto been formed under special Acts of Parliament (incorporating since 1845 and 1863 respectively the general consolidation Acts of those years, above referred to), as the powers required for such an undertaking are too extensive to be obtained by agreement or otherwise without parliamentary sanction. It has, however, recently been provided by the Railways Construction Facilities Act 1862, that where all landowners over whose land a railway is proposed to be made are consenting parties, the promoters of the line may obtain the necessary powers without a special Act, by a certificate from the Board of Trade, the draft of which is to be previously submitted for the sanction of parliament; and in certain cases existing railway companies may obtain further powers (under the Railway Companies Powers Act 1864) by a similar certificate from the Board of Trade. But any such application to the Board of Trade may be rejected by the Board; and if it should be opposed by any railway or canal company which would be affected by the proposed certificate, further proceedings must be in parliament.

It appears to have been originally thought that railways, like highways, would be, to some extent at least, open to the use of the general public; and the Railways Clauses Consolidation Act 1845 contains provisions for the use of the railway, with engines and carriages, by companies and persons other than the company to whom the railway belongs, on payment of certain tolls; but it is found in practice that the difficulties of so doing are so great that the company owning the railway possesses a virtual monopoly of it, except where, as is the case on many lines, other companies have by special agreement or Act of Parliament obtained the power of running their trains over it and using the stations, &c.

Railway companies are as common carriers subject ordinarily to the general law of the land. The Railway and Canal Traffic Act 1854 contains various important provisions binding companies to afford all reasonable facilities for the receiving, and forwarding, and delivering of traffic without unreasonable delay, and without giving any person, or company, or description of traffic any preference or advantage, or subjecting the same to any prejudice or disadvantages, and otherwise regulating their rights and liabilities as carriers.

Rain (Ger. regen, akin to Lat. rigo, Gr. βρέχω, *to moisten*). In Meteorology, water falling from the atmosphere in drops.

The following generally received theory of rain was proposed by Dr. James Hutton in the *Phil. Trans. of Edinburgh* for 1787. The capacity of air for moisture, or the quantity of moisture which a given volume of air will hold, increases with the temperature, but in a much faster ratio than the temperature; and hence it follows that if two equal portions of air at different temperatures completely saturated with moisture are mingled together, a precipitation must take place from the inability of the mixture (which will have the mean temperature of the two portions) to sustain the mean quantity of vapour. For example, suppose that while the temperature increases in an arithmetical ratio, the capacity for retaining moisture increases in a geometrical ratio, and that at the temperature of 15 centesimal degrees air can hold 200 parts of moisture; then at 30 degrees it will hold 400 parts, and at 45 degrees 800 parts. Now, suppose two equal bulks of damp air, at the respective temperatures of 15

and 45 degrees, to be mixed together, the compound must contain 1,000 parts of vapour, or either half of it 500 parts; and the temperature of the compound will be 30 degrees. But at this temperature the air is saturated with 400 parts, and consequently there will be a precipitation of 100 parts from each of the given bulks.

It is obviously not necessary that the commingled portions of air should be fully saturated with moisture, as assumed in the above example: rain will be precipitated if the two masses approach the point of saturation, but the quantity will be proportionally less. It is also a consequence of the theory that for a given difference of heat the precipitation will be greatly increased at the higher temperatures; and this is conformable to experience, for showers are most copious during hot weather, and in tropical countries. The circumstances, therefore, on which, according to this theory, the quantity of rain precipitated in a given time depends, are the following: The previous dampness of the commixed portions of air; the difference of their respective temperatures; the elevation of their mean temperature; and the extent to which the mixture takes place.

The principal objection to this theory is, that the quantity of rain which actually falls in a given portion of time is often very much greater than can be supposed to be produced by any probable extent of cooling that can take place in the free atmosphere in that time, unless, perhaps, we have recourse to the supposition of a cold and a warm current driving swiftly in opposite directions, and continually mixing their conterminous surfaces. Sir J. Leslie (*Ency. Brit.* 'Meteorology') computes that if two currents of moist air were driving along in opposite directions, with velocities whose sum is 30 miles an hour, the one having a temperature of 70° of Fahrenheit, and the other of 50°, the deposition of moisture in the space of an hour would be equal to the height of an inch. If the sum of the opposite velocities amounted to 60 miles an hour, and the intermingling influence extended to but a quarter of an inch at the grazing surfaces, there would still be produced in the same time a fall of rain reaching to half an inch in altitude. These quantities agree sufficiently with observation in certain cases; but the objection still recurs that rain frequently falls from clouds which appear to move very slowly, and when consequently the supposition of such velocities is inadmissible. This difficulty has, however, been recently solved by Prof. Tyndall, who has proved that aqueous vapour possesses a high radiating power, and that consequently a stratum of moist atmospheric air can have its temperature rapidly reduced by the escape of its heat into space through the superincumbent dry air. In connection with atmospheric condensation it must also be borne in mind that the ascent of warm air, necessarily involving expansion, i.e. a motion of its particles away from each other, is always attended by considerable reduction of temperature, and hence, if the warm air be saturated or nearly saturated with moisture, condensation must occur from this cause independently of that which may arise from intermixture with colder air or from radiation.

Some extraordinary falls of rain have been recorded, the accounts of which, if not given on apparently unexceptionable testimony, would scarcely fail to be regarded as fabulous. On the 25th of October, 1825, a fall of 30 French inches (32 English), within 24 hours, occurred at Genoa; and on the 9th of October, 1827, there fell at Joyeuse, in the South of France, a quantity equal to 31 English inches within the space of 22 hours. (Prof. Forbes's Report on Meteorology, in the *Reports of the British Association for* 1840.)

Rain drops vary in size from perhaps the 25th to the 3rd part of an inch in diameter; and, like other falling bodies, descend with a continually accelerating velocity until the resistance of the air becomes equal to their weight, after which the descent is uniform. The terminal velocity is proportional to the square root of the diameter of the drop; but it is perhaps not possible to determine with certainty the actual terminal velocity corresponding to a drop of any given diameter.

The average quantity of rain which falls in a year at any given place depends upon a great variety of circumstances, as latitude, proximity to the sea, elevation of the region, configuration of the country and of the mountain ranges, exposure to the prevailing wind; and in general on the different local causes which influence climate. Humboldt estimates that the average depth of rain which annually falls at the latitudes of 0°, 19°, 45°, and 60°, may be taken respectively at 98, 80, 29, and 17 inches; but this estimate must be regarded rather as a rough approximation to the ratio in which the quantity decreases on going from the equator, than as indicating the actual averages at any particular place; and it is observed that though the annual depth be greatest towards the equator, the number of rainy days in the majority of places increases with the latitude.

The greatest depth of rain which has been registered at any place in a year is at Maranham, lat. 2½° S., and is stated by Humboldt to be 277 English inches. But this is greatly above the average, and indeed more than double the annual quantity which has been observed at any other locality. At St. Domingo the annual fall is estimated at 120 inches; at Cayenne, 116 inches; in the island of Granada, 112; at the Havannah, 91; at Calcutta, from 76 to 118; at Bombay, from 83 to 96; the island of Martinique, 87 inches; and at Sierra Leone, 86. Of European countries, Portugal appears to be the most humid, 123 inches having been observed at Coimbra in a year. The average depth at Paris is 19·1 inches (Arago, *Journal de Physique*, 1816); Berlin, 20·9; Brussels, 19; Florence, 41·3; Lyons, 39·5; Maestricht, 36·1; Marseilles, 18·4; Padua, 36·6; Petersburg, 18·2; Rome, 31·2; Rotterdam,

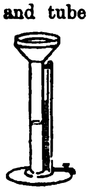
22·4; Stockholm, 18·7; Vienna, 17. For places in Great Britain the following averages were deduced by Dr. Dalton from observations of a number of years: Manchester, 36·140 inches; Liverpool, 34·118; Lancaster, 39·714; Kendal, 53·944; Dumfries, 36·918; Glasgow, 21·331; London, 20·686. Mr. Howard gives the annual average at London as equal to 24·9 inches; Professor Phillips that of York as 25·7; and Mr. Adie that of Edinburgh as 25 inches. On the theory of rain, see Kämptz, *Lehrbuch der Meteorologie*; Muncke, in Gehler's *Physicalisches Wörterbuch*; Daniell's *Meteorological Essays*, &c.

Rain-gauge, also called **Ombrometer, Udometer,** and **Pluviameter.** An instrument for measuring or *gauging* the quantity of rain which falls at a given place.

'The *rain-gauge* may be of very simple construction. A cubical box of strong tin or zinc, exactly ten inches by the side, open above, receives at an inch below its edge a funnel, sloping to a small hole in the centre. On one of the lateral edges of the box, close to the top of the cavity, is soldered a short pipe, in which a cork is fitted. The whole should be well painted. The water which enters this gauge is poured through the short tube into a cylindrical glass vessel, graduated to cubic inches and fifths of cubic inches. Hence, one inch depth of rain in the gauge will be measured by 100 inches of the graduated vessel, and 1-1000th inch of rain may be very easily read off.

'It is very much to be desired that, being of such easy construction, more than one of these gauges should be erected; or at least one placed with its edge nearly level with the ground, and another upon the top of the highest building, rock, or tree in the immediate vicinity of the place of observation, the height of which must be carefully determined, it having been satisfactorily ascertained that the height of the gauge above the ground is a very material element of the quantity of rain which enters it. The quantity of water should be daily measured and registered at 9 A.M.' (*Report of the President and Council of the Royal Society on the Instructions to be prepared for the Scientific Expedition to the Antarctic Regions*, 1840.)

A convenient form of the instrument is represented in the annexed figure, where the rain which enters the funnel is collected in a cylindrical vessel of copper, connected with which at the lower part is a glass tube with an attached scale. The water stands at the same height in the cylinder and glass tube, and being visible in the latter, the height is read immediately on the scale; and the cylinder and tube being constructed so that the sum



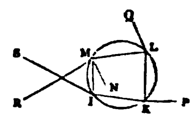
of the areas of their sections shall be a given part, for instance a tenth, of the area of the funnel at its orifice, each inch of water in the tube is equivalent to the tenth of an inch of water entering the mouth of the funnel. A stop-cock is added, by which the water is drawn off when the observation is made.

Rainbow (Ger. regenbogen). The brilliant-coloured arch which makes its appearance when rain is falling in the region of the sky opposite to the sun, and the sun is shining upon the rain-drops at the same time.

This well-known meteor presents, when perfect, the appearance of two concentric arches; the inner being called the *primary*, and the outer the *secondary* rainbow. Each is formed of the colours of the solar spectrum; but the colours are arranged in the reversed order, the red forming the exterior ring of the primary bow and the interior of the secondary. The innermost bow is a segment of a circle whose radius subtends an angle of about 42°; the radius of the outer subtends an angle of about 51°; and the common centre is situated in the prolongation of the straight line which passes through the centre of the sun and the eye of the spectator. From the conditions invariably accompanying its appearance, the colours of the rainbow were known at an early period to be produced by the sun's rays passing through the drops of falling rain; but the phenomenon is a complicated one, and was not fully and satisfactorily explained until Newton had discovered the compound nature of solar light, and the different refrangibility of the component rays.

In order to explain the phenomenon of the rainbow, let us suppose a beam of light admitted through a small hole in the shutter of a darkened room to fall on a spherical globule of water at I (fig. 1) in the direction S I, and trace the path of the light in the interior of the globule. On entering the globule at I it is refracted, and consequently decomposed,

Fig. 1.

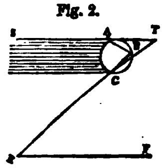


the rays of each colour being deflected under a different angle from its original direction. For the sake of perspicuity we shall confine our attention to the red ray. Let I K be the direction of the ray after the first refraction. On meeting the surface of the drop at K a portion of the light will effect its escape, and be again refracted in the direction K P, while the remaining portion will be reflected by the surface in the direction K L, the lines I K, K L making equal angles with a tangent at K. But on arriving again at the surface at L, this portion of the ray which was reflected from K will be again divided into two parts; one part will escape at L, and be refracted in the direction L Q, while the other part will be reflected by the surface, and proceed in the direction L M. At M the phenomenon will be repeated; part of the remaining light will escape and be refracted in the direction M R, and the other be reflected in the direction M N. This process will be repeated indefinitely; but the intensity of the light is diminished at each successive impact, and after a few reflections the quantity which emerges becomes insufficient to make an impression on the eye. All this may be shown experimentally by causing a beam of light to fall upon a glass

cylinder filled with water, and placed in a darkened room; the red light emerging at the points K L M will be seen when the eye is placed in the straight lines K P, or L Q, or M R.

Applying these considerations to the primary or inner bow, where there are only two refractions and one reflection, let A B C (fig. 2) be a section of a drop of rain made by the plane passing through the centre of the sun, the centre of the drop, and the eye of the spectator; and suppose the rays from the sun's centre to fall on it in the direction S A. Let E be the position of the eye of the spectator, whose back is turned towards the sun, and draw E F parallel to S A. Now suppose the line E T to be drawn so as to make with E F an angle of 42° 1′ 40″, and to meet the drop at C; then, since the whole of the anterior surface of the drop is illuminated by the rays S A, some one of those rays must fall on it under an angle of incidence, such that after being refracted at A, reflected at B, and again refracted at C, it will emerge parallel to C E, and consequently make with E F the maximum angle of deviation. The spectator will therefore see the red colour of the spectrum in the direction E C. But it is obvious that all these conditions will be fulfilled in respect of every drop of rain which the line E C will meet, on supposing it to revolve about E F as an axis at the same angle of inclination. Hence the red rays thus refracted form the surface of a cone, the axis of which is the prolongation of the straight line drawn from the centre of the sun to the eye; and as the eye of the spectator is at the apex of the cone, a circular segment of red light will be visible, the other part of the circle being cut off by the horizon.

Fig. 2.



What has now been said has reference only to rays coming from the sun's centre; but the same thing must happen with respect to rays coming from every point of the sun's disc; and as the sun's diameter subtends an angle of about 30′, the spectator will consequently see a band of red light of the breadth of about 30′.

The explanation which has now been given of the appearance of the red light applies to all the other colours of the spectrum, the only difference being in the value of the index of refraction. For the violet ray, in passing from air to water, the index is $109 \div 81$; we have therefore $n = 1{\cdot}3468$; and on computing from this the values of i, r, and D by means of the preceding formulæ, there results, approximately,

$$i = 58^\circ\, 40'\, 3'',\ r = 39^\circ\, 24'\, 20'',\ D = 40^\circ\, 17'.$$

In this case, therefore, the angle of maximum deviation is less than for the red ray, and hence the violet is within the red. The breadth of the violet band will obviously be the same as that of the red, as both depend on the same cause; namely, the magnitude of the sun's apparent diameter.

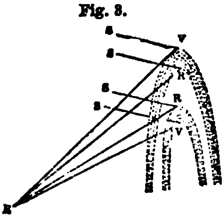
As the red and violet are the rays whose indices of refraction are the least and greatest respectively, all the other prismatic colours will lie between these two, and occupy bands of the same breadth, but with considerable blending into each other; but the distance between the centre of the red and the centre of the violet, being equal to the difference between their respective angles of maximum deviation, amounts only to $42^\circ\, 2' - 40^\circ\, 17' = 1^\circ\, 45'$. The whole breadth of the interior or primary bow is this quantity plus the sun's apparent diameter, or about 2° 15′.

The size of the bow depends upon the height of the sun above the horizon. When the sun is in the horizon, the bow will be a semicircle to a spectator on a plane; but on the summit of a mountain, he may see a segment greater than a semicircle.

The secondary bow is formed as shown in fig. 1.

In this case, the light suffers two reflections in the interior of the globule, and the path of a ray, as represented in fig. 1, is S I K L M R, and the deviation becomes least in respect of the red ray, and greatest in respect of the violet; the order of the colours is therefore reversed, the red occupying the innermost band and the violet the outermost, as represented in fig. 3, where E R is the red and E V the violet ray, the eye of the spectator being at E. The breadth from the middle of the red to the middle of the violet is 3° 10′, or nearly double that of the interior bow. The interval between the red of the interior bow and the red of the exterior is $50^\circ\, 59' - 42^\circ\, 2'$, or 8° 57′. All these values, deduced from the theory of refraction, are found to agree exactly with those found by actual measurement.

Fig. 3.



Dr. Halley, in the *Phil. Trans.* for 1700, has computed the diameters of the rainbows formed by three, four, and five reflections; but these bows are rarely if ever seen, the light being too faint to make an impression on the eye. Supernumerary or spurious rainbows are sometimes seen within the primary and without the secondary bow, and having the same order of colours as the bows to which they respectively belong. They are explained by Dr. Young on the theory of the interference of light. (*Phil. Trans.* 1804; *Lect.* vol. i. p. 470.) An inverted or distorted iris is sometimes observed lying on the ground, formed by the drops of dew suspended from the tops of the blades of grass, or from spiders' webs. In favourable circumstances lunar rainbows are sometimes seen; but their colours are faint and scarcely perceptible.

The first explanation of the true theory of the rainbow is usually ascribed (Newton's

Optics) to Antonio de Dominis, archbishop of Spalatro, and afterwards dean of Windsor, whose work, *De Radiis Visus et Lucis*, was published at Venice in 1611, but stated to have been written twenty years previously. It would appear, however, from the account of this work given by Boscovich, Montucla, Priestley, and Biot, that the merit of De Dominis was confined to a vague statement or surmise, unsupported by experiment, that the interior bow is formed by two refractions and an intermediate reflection. He gave no reason for the precise angle which its diameter subtends; and with respect to the exterior bow, his attempt to explain its formation is wholly erroneous. The true theory of the exterior bow, and the determination of the particular angles of deviation under which alone the rays transmitted to the eye are sufficiently dense to be visible, belong to Descartes. The explanation given by Descartes, in his *Dioptrics*, is complete in every respect, excepting as to the cause of the colours, the theory of which was supplied by Newton's great discovery of the unequal refrangibility of the different rays. (Montucla, *Histoire des Mathématiques*, vol. i. p. 700; Priestley *On Vision*, p. 107; Biot, *Traité de Physique*, tom. iii. p. 460.)

Raised Beach. In Geography, a beach is a shelving tract of sand or shingle washed by the sea or a fresh-water lake, and interposed between the water and the land on which vegetation grows. The beach of the ocean is, generally speaking, little more than the space between low and high water mark; the beach of a lake, that between the water marks of the highest and lowest ordinary level of the lake. An inland sea with little tide, such as the Mediterranean, has generally not much beach, except in embayed portions, where the waters rise or fall according to the prevailing winds. *Raised beaches* are tracts of shingle and gravel, indurated for the most part into the consistency of pudding stone or breccia, found on the sides of shelving ground at a level above that of some neighbouring lake or sea, in such a position as to leave no doubt that they had in ancient times been washed by its waters. They are found extending along our own coast, especially in Cornwall and Wales; they have been observed also very distinctly on the shores of the Mediterranean and the Baltic, and they abound in the vicinity of the great American lakes. They are valuable geological evidence of a recent change in the level, over distinct areas of former sea-bottom, now converted into dry land high enough to be beyond the tidal influence.

Raising Plate or **Upper Plate.** In Architecture, the plate or longitudinal timber on which the roof stands when in its place or pitched.

Raising a Siege. In Military language, abandoning a siege.

Raisins (Fr.; Ger. rosine). The dried berries of the Grape Vine, of which large quantities are annually imported, upwards of 300,000 cwt. having been received in this country in 1864, chiefly from Turkey and Spain. Some are wholly sun-dried, and these, which are the best, are called raisins of the sun. Others are first dipped in a ley, and then sun-dried; others which are dried in ovens, are of inferior quality. The raisins of Malaga are the finest, the muscatels from that district being the most esteemed of all.

Rajah (akin to the Sanscrit root râj, *to shine*: the word reappears in the Latin rex, regis, *a king*). A title given to the hereditary princes of the Hindus, who belong to the Cshatriya or warrior caste. [Caste.]

Rake (A.-Sax. racian). The Nautical term for *slope*, applied in several senses on board ship. The *rake of the stem and stern* is the distance by which the top projects beyond its base where it joins the keel. The *rake of a mast* is its slope towards the stern, causing its angle with the keel to be less than a right angle. The object of this rake is to diminish the plunging action of the ship's bows. It is a common form of masting in small sharp-bowed vessels. The *rake of the rudder* is its foremost edge, agreeing with the sternpost, and of course having the same rake.

To rake a ship, is to fire into her head or stern in the direction of her length, or along her decks. It is similar to what engineers term *enfilading*.

Ram (a Teutonic word). An instrument of modern warfare, reproducing on a vastly more powerful scale the beaked vessels of the ancients. The ram is a ship of extraordinary solidity and strength, propelled by engines of great power, and armed at the prow, below the water line, with a sharp heavy beak nearly pointed and diminishing to a sloping edge on the upper side. This beak is nearly solid, or at least of the strongest possible formation; and it is usually built as an independent adjunct to the ship, so that in the event of any very serious collision it may be buried in its victim, or carried away, leaving the vessel itself intact. Irrespective of this beak, the ram is constructed like any other iron-clad vessel. It may be of iron altogether, of wood with iron armour throughout, or of wood with its battery only protected by armour. Some rams have their batteries in broadside, others in revolving turrets, naval authorities being divided as to the relative advantages of the systems. The shape of the beak, flat beneath, and above inclining upwards towards the ship, presents the exact opposite of the ordinary cutwater in its action on the water; but the French naval architects maintain that the change is an improvement, the throwing off of water from the sharp edge preventing the formation of that mound of water which collects against the bow of the usual build and greatly impedes progress. The first practical use of the modern iron-clad ram was in 1862 in the Hampton Roads, where the Confederate ram 'Merrimac' destroyed several Federal wooden vessels with the greatest ease.

RAM. In Hydraulics. [HYDRAULIC RAM.]

RAM. In Zoology, the perfect male of the species of sheep, e.g. *Ovis Ammon*, *O. musimon*, *O. Vignei*, from one or more of which wild species the domesticated breeds have been derived. The castrate mal eis termed *wether*.

Ram, Battering. [BATTERING RAM.]

Ram-til (Hin. ram-tilla). One of the names of *Guizotia oleifera*, an oil-plant of India. The oil is commonly used as a lamp oil, and as a condiment.

Ramadan or **Rhamadan.** The name given to the great fast or Lent of the Mohammedans. It commences with the new moon of the ninth month of the Mohammedan year; and while it continues, the day is spent uninterruptedly in prayers and other devotional exercises. Even the night is passed by the more rigid of the faithful in the mosques, which are splendidly illuminated on this occasion; but, generally speaking, the arrival of sunset is the signal for a more than usual indulgence; and, on the third evening of the fast, the grand vizier commences a series of official banquets. The Ramadan ends on the day preceding the only other great festival of the Mohammedans, the BAIRAM, equivalent to our Easter.

Ramayana (Sanscr. *the career or travels of Rama*). The oldest of the two great Sanscrit epic poems, describing the life and actions of the hero Rama and his wife Sita, and especially Rama's expedition to Ceylon, to rescue Sita from the tyrant Rawana. For the age of the poem, see Max Müller, *History of Sanscrit Literature*, p. 41, &c. A translation of it was commenced by Messrs. Carey and Marshman (printed at Serampore); and another by A. W. von Schlegel (Bonn 1829). (*Historical Sketch of Sanscrit Literature*, from the German of Adelung, p. 117, &c.)

Ramentum (Lat. *a shaving*). In Botany, a thin brown foliaceous scale, such as appear sometimes in great abundance upon young shoots, and are especially numerous and highly developed upon the petioles and the backs of the leaves of ferns.

Ramists. In Philosophy, the partisans of Pierre Ramé, better known by his Latin name of Ramus, royal professor of rhetoric and philosophy at Paris in the reign of Henry II. He perished in the massacre of St. Bartholomew. His system of logic was opposed to that of the Aristotelian party; and during the latter half of the sixteenth century a vehement contest was maintained between their respective adherents in France, Germany, and other parts of Europe. (Hallam, *Literature of Europe*, vol. ii. ch. iii.) 'He conferred,' says the same writer, 'material obligations on science by denying the barbarous method of the schoolmen. What are the merits of his own method, is a different question.' (*Ib.* vol. i. ch. vii.)

Ramline. In Mast-making or laying a deck, a long line of cord so fastened as to designate the exact central line.

Rammelsbergite. An arsenide of nickel isomorphous with rhombic Iron Pyrites. It is named after Rammelsberg, the German chemist and mineralogist.

Ramnenses or **Ramnes.** [EQUITES; LUCERES.]

Ramp (Fr. rampe). In Architecture, a concave band, or slope, in the cup or upper member of any piece of ascending or descending workmanship. Thus, the ramp of a staircase railing is the inclined rail along which the hand of a person going up or down the staircase is led. The word *ramp* is, however, understood in this case to apply to the straight part exclusively.

RAMP. In Fortification, a road cut obliquely in the interior slope of the rampart, leading from the interior of the work to the terreplein.

Rampant (Fr.). In Heraldry, a term used to describe lions, tigers, bears, &c., when represented as standing erect on their hind legs.

Rampart (Fr. rempart). In Fortification, the mass of earth thrown up from the ditch inwards in order to give the defenders a commanding position over the ground in front. The term *rampart*, though strictly meaning the mound on which the parapet stands, generally includes the parapet itself. If it be of less height than thirty feet, it is liable to be taken by escalade. [FORTIFICATION.]

Ramphorhynchus (Gr. ῥάμφος, *a beak*, and ῥύγχος, *a snout*). A genus of Pterosaurian reptiles, in which the fore part of the jaw is without teeth, and may have been encased in a horny beak, but behind the edentulous production there are four or five large and long teeth, followed by several smaller ones. The tail is long, stiff, and slender. The *Ramphorhynchus longicaudus*, *R. Gemmingi*, and *R. Münsteri* belong to this genus. All are from the lithographic (middle oolitic) slates of Bavaria.

Rampion (Fr. raiponce, from Lat. rapum, *rape*). The garden name for *Campanula Rapunculus*, the fleshy roots of which were formerly cultivated and eaten in this country, as they still are in France and Italy.

Ramus (Lat. *a branch*). In Botany, a term applied to a branch or subdivision of a stem, *ramulus* being a little branch or ultimate subdivision. Hence the word *ramose*, which is applied to plants which produce branches (in contradistinction to such as are unbranched), or to those which are very much branched.

Ran. In Rope-making, a reel of twenty yarns.

Rana (Lat. *a frog*). The generic name of the tailless Batrachian reptiles, which have the hind legs longer than the fore, and webbed toes fitted for swimming, and not expanded at the extremity. Their head is flat, muzzle rounded, and the opening of their jaws large; the tongue in most of them is soft, and not attached to the bottom of the gullet, but to the edges of the jaw, with the free end turned backwards. There are but four toes to the anterior feet; the hind ones frequently exhibit the rudiment of a sixth.

There are no movable ribs to their skeleton: a prominent cartilaginous plate supplies the place of a tympanum, and renders the ear visible

externally. The eye is furnished with two fleshy lids, and a third, which is transparent and horizontal, concealed under the lower one. Inspiration is effected by the muscles of the throat, which, by dilating, draw in air by the nostrils, and by contracting while the nostrils are closed by the tongue compel the air to enter the lungs; expiration, on the contrary, is produced by the muscles of the lower part of the abdomen. The young frog, which is called a *tadpole*, is at first furnished with a long fleshy tail, and a small horny beak, having no other apparent limbs than little fringes on the sides of the neck. These disappear in a few days, and the hind feet of the tadpole are very gradually and visibly developed; the fore feet are also developed, but under the skin, through which they subsequently penetrate. The tail is gradually absorbed. The beak falls and discloses the true jaws, which at first were soft and concealed beneath the skin; and the branchiæ are absorbed, leaving to the lungs alone the function of respiration in which they participated. The eyes, which at first could only be discerned through a transparent spot in the skin of the tadpole, are now visible with their three lids. Tadpoles reproduce their limbs almost like salamanders.

The period at which each of these changes takes place varies with the species. In cold and temperate climates, the perfect animal passes the winter under ground, or in the mud under water, without eating or breathing; though if it be prevented from respiring during the summer for a few minutes by keeping its mouth open, it dies.

Rancierite. A variety of Hausmannite, resembling Pyrolusite.

Randanite. A kind of soluble silica, chiefly composed of infusorial remains, and found in France near Randon, in the Puy-de-Dôme.

Range. In Gunnery, the distance from the muzzle of a gun to the second intersection of the *trajectory* with the *line of sight*. The *range* is not accurately the distance to the point at which the shot impinges on the plane, unless that is also the point aimed at, but the difference is practically of importance only at short distances. In practice the *range* is usually measured from the muzzle of the gun to the point of impact on the object, or to the first graze of the projectile. The range depends on the *initial velocity*, the form and density of the projectile, the *angle of elevation* of the gun, and the difference of level between the planes upon which the gun and object respectively stand.

RANGE. On Shipboard, a length of cable equal to or slightly in excess of the supposed depth of water into which the anchor is about to be cast. It is lightly coiled on the deck, that it may run freely through the hawse-hole as the anchor falls. The term *range* is also used to denote a large cleat in a ship's waist for belaying the sheets and tacks of the courses.

Ranger. Formerly, a sworn officer of the king's forests, whose principal duty it was to see and enquire respecting trespassers in his bailiwicks, and present them at the next court holden for the forest; but now merely an officer of state. [FOREST.]

Ranidæ. The family of Batrachian reptiles, having as the type the frog (*Rana temporaria*, Linn.). [RANA.]

Rank and File. In the Army, all soldiers and non-commissioned officers bearing arms in the ranks are so called.

Ranters. A sect which originated in a secession from the Wesleyan connection, on the ground that the Wesleyans paid too much attention to the externals of public worship, and were deficient in zeal in open preaching in the streets and fields. They admit of female preaching; a thing unknown to every other body of Methodists. They are most prevalent in America.

Ranula (Lat. rana, *a frog*, to which it has been supposed to bear some resemblance). A tumour under the tongue, generally supposed to arise from some obstruction of the ducts of the salivary glands; some recent observations, however, render it probable that the disease often consists in the developement of a cyst in or about the salivary ducts under the tongue.

Ranunculaceæ (Ranunculus, one of the genera). An order of Exogenous polypetalous plants, in almost all cases herbaceous, inhabiting the colder parts of the world, and unknown in hot countries, except at considerable elevations. They are of great importance, from their usually poisonous qualities, as evinced by Aconite and Hellebore in particular, which are the roots of several species. Some of them are objects of beauty, as the Larkspurs, Ranunculus, Anemone, and Peony. [PÆONIA.] A few are simply astringent, as the *Coptis* or Gold-thread of North America. The plants of this order are readily known by having an indefinite number of hypogynous stamens, separate carpels, exstipulate undotted leaves, and a herbaceous stem.

Ranz des Vaches (Fr.; Ger. kuhreihen, *the call to the cows*). The name of the melody which the Swiss herdsmen are in the habit of playing on the Alpine horn, and sometimes of singing, when they drive out their herds to the mountains. It consists of a few simple intervals, and has a beautiful effect in the echoes of the Swiss mountains. The natives are said to be seized with irrepressible longings to return to their native country when they hear it played in a foreign land.

Rape (Lat. rapum, Gr. ῥάπυς). In Botany, the *Brassica Rapus*, a plant belonging to the cabbage family, cultivated in fields for its seeds, which are crushed for oil; and sometimes for its leaves, which are fed off by sheep. In Belgium another variety, called *Colza*, is cultivated for these purposes, the *Brassica Rapus oleifera*.

RAPE (Lat. raptus). In Criminal Jurisprudence, a well-known and detestable offence committed against women. Capital punishment for this offence was abolished in 1841. The substitute is penal servitude or imprisonment.

Rape. An Anglo-Saxon territorial division, of which the etymology is uncertain. Sussex is the only county divided into rapes; each containing three or four hundreds. These subsisted as military divisions at the time when Domesday Book was compiled. They were formerly under the superintendence of *rape-reves*, subordinate to the sheriff of the county.

Raphania (Lat. raphanus, Gr. ῥαφανίς, *the radish*). A disease supposed to be produced by eating the seeds of a species of *Raphanus*. It is attended by convulsive motions of the limbs, vomiting, and diarrhœa, and is classed by Cullen among the *neuroses*.

Raphanosmite. A name given to varieties of Clausthalite having part of the lead replaced by copper.

Raphanus (Gr. ῥάφανος, *a radish*). A genus of *Cruciferæ*, of which the most important species is the Common Radish, *R. sativus*. The Radish was extensively cultivated in ancient Egypt, but does not appear to have reached this country until A.D. 1548. The root, which is the part mostly used, is fleshy and variable in form, in some varieties fusiform, in others round like a small turnip, or semi-globular, and either of a reddish-purple, white, yellowish, or deep brown. The seed-pods are smooth, ending in a short pointed beak, and while young, green, and plump, are used for pickling, alone or with other vegetables; they are also considered a tolerable substitute for capers. It is, however, as a salad-root that radishes have from time immemorial been used. They are in perfection when of a moderate size and quite young. The flesh then abounds in a peculiar nitrous juice, which is much relished by vegetarians, and is considered to be a powerful antiscorbutic. Radishes are usually eaten raw with salt, or cut into slices and mixed in salads. When too large for a salad, they make an excellent dish if dressed and served like asparagus.

The Rat-tail Radish, *R. caudatus*, produces pods which sometimes are as much as three feet long. These, when properly grown, are quite tender and agreeably flavoured, and are eaten instead of the roots, which do not acquire a succulent condition in this species.

Raphe (Gr. ῥαφή, *a seam*). In Anatomy, a term applied to parts which look as if they had been sewn or joined together.

Raphe. In Botany, the vascular cord communicating between the nucleus of an ovule and the placenta, when the base of the former is removed from the base of the ovulum.

Raphia (Gr. ῥαφή). A genus of Palms, the three species of which are found in three widely separated but very limited localities in Brazil, tropical Africa, and Madagascar. The American species, *R. tædigera*, called the Jupati Palm, has cylindrical leafstalks, which measure from twelve to fifteen feet in length, and are used by the natives of the Amazon for a variety of purposes; the walls and partitions of their houses being often constructed of them, while baskets, boxes, &c., are made of strips of the smooth outer portion. *R. vinifera*, the Bamboo Palm, which grows on the west coast of tropical Africa, is employed for similar purposes by the Africans, who also make very pliable cloth and neat baskets of the undeveloped leaves. Palm-wine is obtained from it, whence its Latin specific name. The fruit spikes sometimes weigh as much as from 200 lbs. to 300 lbs.

Raphides (Gr. ῥαφίς, *a needle*). In Botany, certain needle-like transparent bodies found lying in the tissue of plants. They were formerly thought to be peculiar organs, but are now known to be the crystals of various salts.

Raphilite (Gr. ῥαφίς, and λίθος, *stone*). A variety of Asbestiform Tremolite, occurring in groups of delicate acicular crystals (whence the name) of a white or bluish-green colour. It is a silicate of magnesia and lime, and is found at Perth, in Upper Canada.

Rapparee. A wild Irish plunderer. The name is supposed to be derived from the rapery, or pike carried by such marauders.

Rappee. A name used to denote those snuffs which are prepared by grinding the tobacco to powder in a moist state.

Raptores (Lat. *plunderers*). Rapacious birds or raveners. The name of the order of birds called *Accipitres* by Linnæus and Cuvier, including those which live by rapine, and are characterised by a strong, curved, sharp-edged, and sharp-pointed beak, and robust short legs with three toes before and one behind, armed with long, strong, crooked talons.

Rarefaction (Lat. rarefacio, *I rarefy*). In Physics, an augmentation of the intervals between the particles of matter, whereby the same number of particles occupy a larger space. The term is used chiefly in speaking of the aëriform fluids, the terms *dilatation* and *expansion* being applied in speaking of solids and liquids. In the free atmosphere rarefaction is caused by diminishing the pressure, and hence the air becomes rarefied when it ascends. The limits to which rarefaction may be carried are not known; but it has been proved by experiments with the air-pump, that air may be rarefied so as to occupy a volume 13,000 times greater than it occupies under the ordinary pressure.

By first filling the receiver with carbonic acid gas, then rarefying by the pump as far as possible, and finally absorbing the small residuum of carbonic acid by solid caustic potash, rarefaction has recently been carried much further; nevertheless, Gassiot has proved that a long vertical tube containing this extremely attenuated atmosphere, still contains as much of it at the top as at the bottom.

Raskolniks (Russ. raskolo, *a division*). The name of the largest and most important body of dissenters from the Greek church in the Russian dominions. They designate themselves Starowerzi, or *the Orthodox*; but differ from the Greek church only in the outward forms of religion, and in maintaining a more strict ecclesiastical discipline. This body was

formerly subjected to persecution, but is now treated with comparative toleration, though its members are still excluded from the service of the state. Their number is said to be about 300,000.

Rasores (Lat. rado, *I scratch*). Gallinaceous birds, or scratchers. The name of an order of birds, including those which have strong feet, provided with obtuse claws for scratching up grains, &c., and the upper mandible vaulted, with the nostrils pierced in a membranous space at its base, and covered by a cartilaginous scale. [GALLINACEÆ.]

Raspberry (Gr. kratzbeere). The *Rubus Idæus*, one of our somewhat local wild plants, related to the bramble. There are many cultivated varieties, in which the fruit is much larger than in the original wild form. The grateful sub-acid fruit is highly valued for confectionery.

Raspberry-jam Tree. A colonial name for the Stinking Acacia of Central and Western Australia, the heavy wood of which has an odour resembling Raspberry jam.

Rat (A.-Sax. ræt, Ger. ratte, perhaps akin to Lat. rodo, *I gnaw*). The name of a large, destructive, and very prolific species of the genus *Mus* (*Mus decumanus*, Linn.), introduced into the British Islands from Asia; not, as is commonly believed, from Norway. It has spread over all the country, and multiplied at the expense of the old British species called the *black rat* (*Mus rattus*, Linn.). [MUS.]

Ratafia. A term applied to certain liqueurs or drams; it is said to have signified originally a liquid drunk at the *ratification* of an agreement. (Pereira *On Food and Diet.*) [LIQUEURS.]

Ratans, Rattans (Malay rotan), or **Canes.** The long slender stems of a species of *Calamus Rotang* and other allied species of Palm, which are among the most useful plants of the Malay peninsula and the Eastern islands, whence they are largely exported. For canework they should be chosen long, of a bright pale yellow colour, well glazed, and of a small size; not brittle or subject to break. They are purchased by the bundle, which ought to contain 100 ratans, having their ends bent together, and tied in the middle. In China they are sold by the picul, which contains from 9 to 12 bundles. Such as are black or dark-coloured, snap short, or from which the glazing flies off on their being bent, should be rejected. When stowed as dunnage, they are generally allowed to pass free of freight. The imports into this country are considerable. (*Com. Dict.*)

Ratchet. In Clock and Watch Work, the name given to an arm or piece of mechanism, one extremity of which abuts against the teeth of a *ratchet wheel*, and the other extremity is either freely jointed to a reciprocating driver for the purpose of communicating a continuous motion to the wheel, or is attached to a fixed centre to insure the wheel against reverse motion. In the former case it is also called a *click* or *paul*, in the latter a *detent*.

Ratchet Wheel. A wheel having teeth formed like those of a saw, against which the ratchet abuts. [RATCHET.]

Rate of Sailing of a Vessel. Various plans have been proposed for measuring the rate of sailing of a vessel, by various forms of the LOG, by which it is now measured; by the rise of water in tubes communicating with the sea; and (according to a suggestion by Captain Burney) by the pressure upon a body towed astern and pulling on a spring. But the violence and irregularity of the pull, and the uncertainty in reading the result, have probably combined to set aside this last plan, which, in theory, seems to promise some advantages; because the pressure, increasing as the square of the velocity, would show very small changes of velocity: for the same reason, however, the mean result shown in a heavy sea would be too great. A certain and simple method of ascertaining the velocity at any instant, with precision, is one of the most important desiderata towards the perfection of naval science.

Rate of a Ship. [NAVY.]

Rathoffite. A variety of Garnet found in Sweden, accompanied by calc spar and hornblende.

Ratification (Lat. ratus, *determined*, and facio, *I make*). The solemn act by which a competent authority gives validity to an instrument, agreement, &c. The term is ordinarily used in international law for the sanction given by governments to treaties contracted by their representatives. In French law, ratification is defined to be the approbation or confirmation of what has been done or promised. Thus, in many instances, a person, on attaining his majority, ratifies acts done by himself or his guardian in his minority. This ratification may be either express or tacit; the latter resulting, by implication, from his silence for ten years after attaining his majority.

Ratio (Lat.). In Geometry, this word is defined by Euclid (*Elements*, book v. def. 3) to be 'a mutual relation of two *magnitudes* of the same kind to one another in respect of *quantity*.' This definition has been much criticised. Dr. Barrow (*Lectiones Math.*), who calls it a metaphysical definition, since nothing in mathematics depends on it, or can be deduced from it, supposes that Euclid had probably no other design in making it than to give a general summary idea of ratio to beginners. It has been remarked, that as the word *quantity* in our language, if not quite synonymous with magnitude, has a signification only a little more general, the definition as above rendered is either tautological or unmeaning. Dr. Simson supposes it to be the interpolation of some unskilful editor. Leslie (*Elements of Geometry*) ingeniously supposes that the Greek word πηλικότης, which is usually translated *quantity*, may have reference to *multitude* or number, as well as to magnitude, and that Euclid's definition may be rendered as follows: 'Ratio is a certain mutual habitude of two homogeneous magnitudes with

respect to *quotity*, or numerical composition.' Dr. Wallis (*Opera Mathematica*, tom. ii. p. 665) translates the same word by the Latin *quantuplicitas*, which refers to the number of times the one magnitude is contained in the other. Dr. Peacock (*Algebra*, p. 309) remarks, that there is no geometrical definition of ratio by which the equivalence of different modes of representation may be ascertained as necessary consequences; and for this reason ratios in geometry are considered only in connection with each other, as constituting, or not constituting, a proportion. In arithmetic and algebra, a ratio may be defined as the fraction of which the numerator is the antecedent, and the denominator the consequent of the ratio; hence, in those sciences, the theory of ratios becomes identified with the theory of fractions. (For an account of what has been written on the subject of geometrical ratios, see Camerer's *Euclid*, Excursus ad lib. v. Berlin 1825.)

Ratios, Prime and Ultimate. [Prime and Ultimate Ratios.]

Ration. In the Army, a portion of food allowed to each soldier for his daily maintenance. [Provision.]

Rational (Lat. rationalis). An algebraic or arithmetical quantity is said to be *rational* when it can be expressed in finite terms without the aid of symbols denoting the extraction of roots; when it cannot be thus expressed, the quantity is termed *irrational*.

Rational Horizon. In Geography, the plane passing through the centre of the earth parallel to the *sensible horizon* of the place to which it is referred. [Horizon.]

Rationalism. The opinion is not uncommon that the history of thought from the age of the Reformation has exhibited a new element, and that this element is the spirit of rationalism. From this it is inferred that some systems, religious or political, may be based on rationalism, while others may exist in spite of it or without it. The inference and the opinion from which it is drawn seem to be alike fallacious. Rationalism is, strictly, nothing but the exercise of reason, and involves the rejection of all conclusions for which evidence sufficient to satisfy the reason cannot be produced. The truth or the falsehood of the system depends, not on the spirit by which they who accept it are animated, but by the adequacy or inadequacy of the evidence alleged in support of it. The conclusions must in every case accord or disagree with the facts for which they account, or are supposed to account. Hence, the most absurd and superstitious systems are as much the growth of rationalism as any which we regard as wholesome or enlightened. The assertion that devils carried witches to midnight feasts in the Harz forest, was as rationalistic as the assertion that there could be no such feasts because there are no devils. The transportation by devils was a rational explanation to account for an alleged fact. The whole question is thus resolved into one of evidence; and it is precisely in the knowledge of the nature of evidence that modern thought is pre-eminently distinguished from that of the middle ages. The complete ignorance of mediæval jurists on this subject is sufficiently shown by the use of Ordeals, judicial combats, and compurgations, as means for ascertaining whether an alleged fact did or did not take place; and as long as men were content with the vaguest notions, or with no notions at all, on the sources of knowledge, their practice could not be essentially changed. But as soon as the dawn of physical science began to reveal the connection of phenomena, the idea of likelihood took root, and the conclusion was reached that the sole source of knowledge is experience, and that in judging of matters of fact no authority or evidence can be admitted except that of experience. Hence, in the case of all theories which professed to explain facts, it was seen that the theory was inadmissible until every single proposition involved in it was established by adequate evidence. Thus, on the hypothesis of devils transporting witches through the air to nocturnal banquets, the explanation cannot be received until it has been proved not only that there are devils, but that they act in some particular ways. That the judges and inquisitors of the middle ages were not competent persons in the ascertainment of facts, must be felt by all who have compared their judicial processes with those of the most recent times, defective, and in part wrong, as these are still admitted to be. During those ages, deliberate and wholesale perjury was the rule, not the exception; and witnesses and magistrates alike were as incapable of sifting the evidence for alleged facts in their own day, as they were of testing the histories or traditions of former times.

It follows that the superstitious beliefs of the middle ages fell, not from the growth of a new spirit, or in spite of an overwhelming amount of evidence in their favour, or from any conviction of their absurdity, but because it became continually more manifest that the assertions dignified by the name of evidence were no evidence at all, and because any alleged facts could be admitted only as agreeing with the standard of likelihood afforded by general experience. The more recent theories of astronomy owed their success not to any supposed absurdities in older theories, but to the measure in which they accorded with or explained phenomena. The idea of antipodes, or of the revolution of the earth round the sun, was scouted as utterly absurd; yet no ideas could be more true. Socrates was firmly convinced that the heat of summer was caused by the approach of the sun to the earth, and regarded the supposed fact as striking evidence of design in the creation of the world; but, although there was nothing absurd or childish in his conviction, it does not square with facts, and therefore must be given up. Hence, it became clear that all assertions could not, as such, stand on the same footing or carry the same weight. The statement that a man was seen

walking at a given hour in a given place must be tested like all other statements; but we at once exclude on the ground of unlikelihood or impossibility the statement that he was seen carrying his head under his arm.

But although rationalism is not a new element introduced into modern thought as contrasted with that of the middle ages, the gradual discovery of the nature of evidence has established conclusions fatal to the authority of any system which refuses to submit its claims to full and fair examination. These conclusions are the result of researches in the physical world, but they issue in the establishment of toleration, which, it has been said, is justified by scepticism, and by nothing else; for, until men are convinced that reason alone can guide us to the truth of facts, toleration is an impossibility. As soon as they are so convinced, they must see that different minds will, from the same facts viewed in different aspects, form different conclusions, although the truth of the facts remains the same, and cannot be divided. For a more full examination of the subject, see an able review of Mr. Lecky's *History of Rationalism* in *Fraser's Magazine* for November 1865.

As the application of the word *rationalism* to denote the writings of any particular school of theologians is thus shown to be inappropriate, it becomes unnecessary to compare the writings of so-called rationalists in Germany, or elsewhere, with those of writers who differ from them only in the degree of evidence on which they are prepared to admit the truth of particular statements or theories. It may be enough to say that the name *Rationalists* has been applied especially to the school of Paulus and other German writers, who seek to convert the miraculous narratives of the New Testament into a relation of ordinary occurrences. Thus, the feeding of the multitudes with the loaves and fishes is explained by the statement that when at the bidding of Christ the disciples had produced their little store, others also brought out what they had with them, and thus a meal was provided for the whole crowd. Measured by the modern standard of likelihood, such explanations may perhaps be considered as involving difficulties scarcely less than those of the narratives for which they profess to account. The influence of such a school was not likely to be lasting, and it was succeeded by another, commonly known as the mythical, which regards the Gospel records as assertions of floating myth round a nucleus of historical fact. For the history of these two schools, see Mackay, *History of the Tübingen School and its Antecedents.*

Ratlines. Small horizontal lines or ropes extended between the several shrouds on each side of a mast, thus forming the steps of ladders for going up and down the rigging and masts. To *rattle* the rigging, is to fix these ratlines.

On ship-rigged masts, the shrouds are ratlined up to the topmast-head: in small vessels or on sloop-rigged masts, only to the top of the lower-mast.

Ratoffkite. A granular or earthy blue variety of Fluor, from Ratoffka in Russia.

Ratoons or **Rattoons** (Span. retoño). The young shoots of the Sugar-cane, *Saccharum officinarum.*

Rattany. [RHATANY.]

Rattlesnake. One of the most deadly of poisonous serpents is so called, from the peculiar rattling instrument at the extremity of the tail, formed of several horny flattened rings, loosely attached together, which move and rattle whenever the animal shakes or alters the position of the tail. These rings increase in number with the age of the animal, and it is asserted that it acquires an additional one at each casting of the skin. The generic name of the rattlesnake, *Crotalus* (Gr. *κρόταλον, a rattle*), relates to the above-mentioned peculiarity. Two species are well distinguished; viz. the *Crotalus horridus* of the United States, and the *Crotalus durissus* of Guiana. The genus is peculiarly American. In common with the boa, the rattlesnakes have simple transverse plates beneath the body and tail. Their muzzle is hollowed by a little round depression behind each nostril. The habits of the rattlesnake are sluggish; they move slowly, and bite only when provoked, or for the purpose of killing their prey. They feed principally upon birds, rats, squirrels, &c., which it is believed they have the power of fascinating.

Rattlesnake Root. The root of the *Polygala Senega*, a stimulant said to be a serviceable remedy in cases of the bite of the rattlesnake.

Rauchkalk (Ger.). A variety of Dolomite, occurring in the Zechstein of North Germany. The signification, *smoky limestone*, refers to its dark colour and bituminous odour.

Ravelin (Fr.). In Fortification, a work composed of an ordinary rampart with a ditch in front, forming two faces meeting in a salient angle, on the perpendicular produced, and directed so as to receive flank defence from the body of the place. It is bounded at its gorge merely by a counterscarp, so that its interior may be exposed to the fire of the works in its rear. Within the ravelin, but separated by a ditch, is constructed a work called the *redoubt of the ravelin.* [FORTIFICATION.]

Raven (A.-Sax. hræfn: for the history of the root *ru* or *kru*, from which the name is derived, see Max Müller's *Lectures on Language*, first series, 348). A species (the largest known in Europe) of the restricted Linnæan genus Corvus, found from Greenland to the Cape of Good Hope, and from Hudson's Bay to Mexico. It is also met with in the Sandwich isles. Ross has pointed out that it is one of the few birds capable of enduring the severities of heat and cold without undergoing any change of plumage. Pied individuals are not unfrequent. It shares with other members of the genus the habit of pilfering shiny objects,

which are of no use to it, either as food, or to aid in the construction of its nest.

Ravenala. A fine Mussaceous plant found in Madagascar, and remarkable for its large leaves and palm-like habit. It forms a noble tree, which the French call the Traveller's Tree, probably on account of the water which is stored up in the large cup-like sheaths of the leafstalks, and which is sought for by travellers to allay their thirst. The very large broad oblong leaves are used as a thatch to cover huts. The seeds are edible, and the blue pulpy aril surrounding them yields an essential oil.

Ray (Lat. radius, *a ray*). A genus of cartilaginous Plagiostomous fishes, recognisable by their horizontally flattened and broad disc-shaped body, which is chiefly composed of the immense pectoral fins, the jointed and branched rays of which diverge, like the rays of a fan, and support a broad duplicature of the skin, which is continuous anteriorly with that of the side of the flattened head; whence the name of the genus. The *Raiæ* of Linnæus are now divided into many subgenera, of which the sting ray, eagle ray, electric ray, fire flare, skate, &c. are the respective types.

RAY. In Botany, the spreading ligulate florets in the flower-heads of the *Compositæ*.

RAY. In Geometry, a straight line, of unlimited length, drawn through a fixed point. [PENCIL.]

RAY. In Optics, a beam of light propagated in a straight line from some luminous point. A ray of white light may be divided by refraction into a number of distinct rays of different colours. [REFRACTION.]

Rayah. The designation by the Turkish government of its non-Mohammedan subjects, who pay the capitation tax. Under Bajazet I. the taxable rayahs in European Turkey were numbered at 1,112,000. At present the tax paid by 'unbelievers' consists in a compensation for freedom from military service. This amounts to rather more than half a million sterling annually. The number of the non-Mohammedan element in the Turkish dominions is computed at fourteen millions out of a population of thirty-five millions, but the proportion of Christians is probably underrated.

Rayonné, Rayonnant or **Radiant.** In Heraldry, a line in zigzag supposed to represent the rays of the sun, or what is commonly called *vandyked*. [HERALDRY.]

Razee (Fr. rasé, Lat. rasus, *shaved* or *scraped down*). The term used for any vessel cut down to a less number of decks, as a two-decker to a frigate, &c. By razeeing, the draught of water is diminished, while the centre of gravity is lowered, and the qualities of the vessel have generally, though not invariably, been improved.

Re. The French and Italian name for the note corresponding to our D.

Re-enter. In Engraving, a word which denotes the passing of the graver into those incisions of the plate, so as to deepen them, where the aquafortis has not bitten in sufficiently.

Re-entering Angle. In Fortification, an angle of which the point projects inwards, towards the work.

RE-ENTERING ANGLE. In Geometry, an angle of a polygon is said to be *re-entering*, when its vertex and the polygon itself fall on the same side of the line joining the two corners of the figure between which the angle is situated. [POLYGON; SALIENT ANGLE.]

Re-entering Places of Arms. In Fortification, spaces provided at the re-entering angles of the counterscarp for the assembly of troops either for sorties or defence. They are formed by carrying the crest of the glacis outwards so as to form a salient angle or an arc of a circle.

Reach (A.-Sax. recan; Ger. reichen; Gr. ὀρέγω, *to stretch out*). That portion of the length of a river in which the stream preserves the same direction.

Reaction. In Mechanics, this term is best defined by Newton's third law of motion, according to which 'action and reaction are equal and in contrary directions;' in other words, the mutual actions of two bodies are always equal and in opposite directions. Thus, when a pistol is fired, the reaction on the holder is equal to the action on the ball.

Reaction, Reactionary. In Politics, words which seem to have been first used to denote the tendencies of those who, after the violent changes effected by the first French revolution, were desirous of bringing back the former state of things; and hence applied in similar cases.

Reaction Wheel. [HYDRAULIC DANAIDE.]

Reader. In Ecclesiastical matters, one of the five inferior orders in the Roman Catholic church. In the church of England, a reader is a deacon appointed to do divine service in churches and chapels of which no one has the cure. There are also readers (priests) attached to various eleemosynary and other foundations. (Hook's *Church Dictionary*.)

READER. In Printing, the person whose duty it is to read proofs in a printing office, and mark all kinds of errors for correction.

Reagent. In Chemistry, bodies which serve to detect the presence of others are termed *reagents* or *tests*.

Real. A Spanish coin. [MONEY.]

Real Actions. In English Law, real actions were formerly the appropriate legal remedy for the recovery of lands, tenements, and hereditaments. It is obvious that land wrongfully held can always be restored to the right owner, while goods may have perished or been consumed, and the term *real action* probably originated in the circumstance that the plaintiff in such a proceeding demanded the specific thing (*res*) abstracted, and not, as in the case of a *personal* action (*actio in personam*), satisfaction in damages to be paid personally by the wrongdoer in respect of some injury done to person or property. The common division of property into *real* and *personal* arose, no doubt,

from this distinction between the legal remedies appropriated to each class respectively. Real actions were of a very complicated nature, and in modern times were almost entirely superseded in practice by the action of *ejectment*, which by a series of ingenious legal fictions had been moulded so as to afford a more prompt and satisfactory remedy for the same class of injuries. [EJECTMENT.] They were ultimately abolished by statute (3 & 4 Wm. IV. c. 27), with two or three exceptions, the most important of which is the action of *quare impedit*, which still forms the common process for trying the right to an advowson, and has recently been remodelled and simplified.

Real Presence. [TRANSUBSTANTIATION.]

Real Property. Real property is commonly said to consist in *lands*, *tenements*, *and hereditaments*. The first of these terms needs no explanation; the second refers to the circumstance that all land in this country is still considered to be the subject of *tenure*, and to be held either of the crown or of some inferior lord; and the third expresses what logicians would term the *difference* of real property, viz. that it descends to the heir wherever held in perfect right 'unless disposed of by will,' and is thus distinguished from personal property (goods and chattels), which, if possessed in equally absolute right, vests in the executors or administrators of the party, for the benefit of his legatees or next of kin. The original division of property was, no doubt, into *immovables* and *movables*; lands, tenements, and hereditaments being included in the first class, while the second was known as goods and chattels. The terms *real property* and *personal property* appear to have originally arisen from the technical distinction between real actions and personal actions, the respective legal remedies appropriated to the two classes of property. [REAL ACTION.] In the course of time, however, so many fresh kinds of property have arisen and become common, that 'the simple division into immovable tenements and movable chattels is lost in the many exceptions to which time and altered circumstances have given rise. Thus shares in canals and railways, which are sufficiently immovable, are generally personal property, whilst a dignity or title of honour, which one would think to be as locomotive as its owner, is not a chattel but a tenement.' (Williams *On Real Property*.) Thus, again, a lease for any number of years (even a thousand) is personal property, because the most ancient leases were farming leases, and the farmer was regarded rather as a bailiff than as the owner of an interest in land. Accordingly, the classes of property are now more commonly distinguished by the terms *real* and *personal*, than by the old division into tenements and hereditaments, goods and chattels, although these phrases, and particularly the word *hereditaments*, are of frequent use in legal documents as convenient and comprehensive terms. Real property is again subdivided into *corporeal* and *incorporeal* property, the former term denoting land with its visible adjuncts recognised by law as appertaining to it, consisting principally of things growing, erected, or fixed thereon, and the latter term including advowsons, rights of way and common, offices, dignities, franchises, rents, and the like. The great practical distinction between corporeal and incorporeal property formerly was that the latter, being incapable of manual transfer, was alienable by writing only, while corporeal property might be transferred by the delivery of possession accompanied by certain solemnities. Real property of every description, however (except copyhold), is now commonly transferred by deed. [COPYHOLD; TENURE.]

Realgar. Native tersulphide of arsenic; composed, when pure, of 70 per cent. of arsenic and 30 of sulphur. It occurs crystallised and massive, of various tints of aurora-red, chiefly in Hungary and Transylvania. Artificially prepared Realgar is used as a pigment; the ancients, who employed it for the same purpose, called it Σανδαράκη or Sandarac.

Realism. In Philosophy, this term has two distinct meanings, as used in contradistinction to *idealism* or to *nominalism*; in the former case it relates to the theory of perception, in the second to the theory of abstraction and generalisation. For the first, see IDEALISM and PERCEPTION; for the second, NOMINALISTS, SCHOLASTIC PHILOSOPHY, SCOTISTS, and THOMISTS.

Ream (A.-Sax.; Dutch riem, Dan. reem). A quantity of paper, consisting generally of twenty quires of twenty-four sheets each. The printer's ream contains 21½ quires, or 516 sheets. [PAPER.]

Reaping (A.-Sax. ripan, akin to Lat. rapio, Gr. ἁρπάζω, *to seize*). Cutting down corn or pulse with a sickle, hook, or scythe, or by a reaping machine. These operations are more advantageously performed when the corn or pulse is not quite ripe, than when it is thoroughly ripe; because in the latter case the seeds are apt to drop out in the process of handling, turning, and drying.

Reaping Machine. Since the International Exhibition of 1851, the American reaping machine, then first shown in this country, has gradually won its way in English agriculture, and there are now many counties in which much the larger portion of our corn crops are cut by it. The American reapers by Hussey and M'Cormick, and others, are, however, no doubt of English or Scottish origin, being essentially the same as the reaper invented long ago by the Rev. Mr. Bell of Forfarshire, and used ever since upon the farm of his brother. The cutting apparatus is an oscillating horizontal knife, having an edge either serrated, or if smooth presenting deep almost finger-shaped cutters. It oscillates through slots in a number of fixed horizontal fingers, which, as the machine is drawn or pushed forwards, hold the straw of the standing corn amidst which they project while the

oscillating knife is continually cutting it. The corn as it is cut falls upon a platform extending backwards from the cutting apparatus, and thence it is either raked in sheaves by a man who rides upon the machine, or it is there received upon a revolving web by which it is carried to one side and let fall in a swathe upon the stubble. The use of the reaping machine is a welcome economy in harvest time, when hand labour is costly, and when rapidity as well as efficiency of work is of the utmost consequence.

Rear (Fr. arrière). Formerly, when a fleet advanced in order of battle in three lines, the hindermost was the rear line or squadron, and furnished the title of the *rear-admiral*, the third officer in command, the first two lines being under the admiral and vice-admiral. At the present day this formation of a fleet is obsolete; but the title survives in the rank of rear-admiral, who represents the third, and lowest permanent, grade of flag officer. The French style this officer a *contre-amiral*.

Rear-check Carriage. In Artillery, a garrison carriage which has a block of wood in rear, resting on the platform, and no rear axle-tree or trucks.

Rear Guard. That part of an army, regiment, or detachment, which marches after the main body. The rear guard brings up stragglers, and protects the rear of the main body of troops.

Reason (Lat. ratio). Like most of the terms in the science of mind, the word *reason* has been employed in a great variety of significations. Dugald Stewart takes it in its widest sense, and comprises under it all the operations of the intellect upon the materials of knowledge which are furnished in the first instance by sense and perception. Its office is to distinguish the true from the false, right from wrong, and to combine means for the attainment of particular ends. Mr. Hume, however, withdraws the discernment of right and wrong, and of the beautiful and its contrary, from the domain of reason; and, on the other hand, also, denies the certainty of the truth which it enunciates. Locke in one passage declares reason to be the faculty which finds out the means, and rightly applies them, to discover either the certain agreement or disagreement of two ideas, or their probable connection. But, in another place, it is said to be conversant with certainty alone; while the discovery of that which, as probable, enforces a contingent assent or opinion, is ascribed to an especial faculty, which is called the judgment. Bird, on the other hand, confines the latter term to the apprehension of intuitive truth; but agrees so far with Locke as to make it one part of reason, of which the other part is reasoning, both demonstrative and moral. On the whole, however, it is clear that in the mind of Locke the terms *reasoning* and *reason* were nearly, if not quite, equivalent. But reasoning and deduction, it is urged by others, are evidently not the source either of the dignity or the authority of the human intellect, for if there were not in the human mind something primary, unconditional, and absolute, to which all reasonings might be referred, as to their source and foundation, the discursive process would proceed into infinity, and its conclusions be, as Hume asserts that they are, without any power to enforce assent. Hence it is maintained that there are unquestionably in the human mind certain necessary and universal principles, which are themselves above proof, but the authority for all mediate and contingent principles, and that that which is thus above reasoning is the reason.

In the language of English philosophy, the terms *reason* and *understanding* are nearly identical, and are so used by Stewart; but in the critical philosophy of Kant a broad distinction has been drawn between them. Reason is the principle of principles; either speculatively verifies every special principle, or practically determines the proper ends of human action. Approximately, it may be called the sum of what, in Scotch philosophy, has been denominated the laws of man's intellectual constitution. The understanding, on the other hand, is coextensive with the vernacular use of reason; It is that which conceives of sensible objects under certain general notions, which again it compares one with another, or with particular representations of them, or with the objects themselves. It is, therefore, the faculty of reflection and generalisation. But the act of comparison is called a *judgment*; and the understanding, when it enunciates its conceptions, becomes also the faculty of judging. But the truth of a proposition which is not identical cannot be immediately certain. To prove it, recourse must be had to other propositions previously admitted; i.e. the understanding must deduce one judgment from another, and so it becomes the discursive faculty, or reasoning. Further, in discovering these mediate truths, and in the regular and methodical disposition of them for the purpose of conclusion, as well as in the selection of means for the accomplishment of its ends, it exhibits itself as a power of adaptation.

The faculty of generalisation has its necessary result in articulate speech; and the ultimate distinction between human nature and that of brute animals is found in the possession by man of this power of abstraction, and not in a contrast of brute instinct with human reason. [Language.]

Reaumuriaceæ (Reaumuria, one of the genera). A small natural order of hypogynous Exogens, referred by Lindley to the Guttiferal alliance, and related to *Hypericaceæ*. They are distinguished by their oblique glandular petals, their few shaggy seeds, and their long distinct styles. *Reaumuria vermiculata* is used at Alexandria as a cure for the itch.

Rebate (Fr. rebattre, *to beat down*). In Architecture, the groove, recess, or channel sunk on the edge of any piece of material.

Rebate. In Trade, a discount or allowance for prompt payment. It is employed in a somewhat different sense in estimating the

assets of a bank. When a bank discounts a bill of exchange, it pays or gives credit to its customer for the bill, minus the market or special rate of discount charged for the postponement of its claim as the negotiator. When, therefore, the present value of the securities held by a bank is estimated, it is necessary to value the bills which it possesses according to the time which they have to run before reaching maturity, and deduct the sum so estimated from their nominal value.

Rebec. A Moorish word, signifying a stringed instrument somewhat similar to the violin, having three strings tuned in fifths, and played with a bow. It was introduced by the Moors into Spain.

Rebellion, Civil. In Scottish Law, by a peculiar fiction, a debtor who disobeys a charge on letters of horning to pay or perform in terms of his obligation was accounted a rebel, by reason of his disobedience to the king's command contained in the writ. (Sir W. Scott, *Antiquary*, ch. xviii.) The penal consequences formerly attaching to this construction of the law were abolished by 20 Geo. II. c. 50.

Rebellion, The Great. In English History, the revolt of the Long Parliament against the authority of Charles I. is commonly so denominated.

Rebus. An enigmatical representation of a name or thing by using figures for letters, syllables, or parts of words: thus an eye, and a ton or barrel, represent the family name of Eyton, an instance of a rebus borne by way of device, as they very commonly were. The term is said to be derived from an annual practice of the priests of Picardy, which consisted in satirising the people of their vicinity on the recurrence of the Carnival in ingenious squibs, entitled 'De *rebus* quæ geruntur.' [DEVICE.]

REBUS. In Heraldry, a coat of arms alluding to the name of the bearer (otherwise called *armes parlantes*) is also called a *rebus*; e.g. three trouts for Troutbeck, three cups for Butler, &c.

Rebutter. In Law, the fifth stage of the pleadings in a suit, or the plaintiff's answer to the defendant's rejoinder. [PLEADING.]

Receiver. In Chemistry, this word generally denotes a globular vessel applied to a retort, and in which the *distillate* or product of distillation is collected or received. The bell-glass placed upon the plate of an air-pump is also called a *receiver*. [RETORT.]

Receiving Stolen Goods. The act of receiving stolen goods, knowing them to be stolen, is, in English Law, a felony by statute. Since the last criminal law enactments (24 & 25 Vict. c. 96) there are three ways of proceeding against a receiver: (1) as for a substantive felony, whether the principal felon has, or has not, been convicted; (2) as an accessary after the fact, where the principal felon has been convicted, or is amenable to justice; (3) jointly with the principal in the same indictment.

Receptacle (Lat. receptaculum, *a storehouse*). In Botany, this term has several significations, denoting, 1. that part of a flower upon which the carpels are situated, or, in other words, the apex of the peduncle, or summit of the floral branch, of which the carpels are the termination; 2. that part of the ovary from which the ovules arise, and which is commonly called the placenta; 3. that part of the axis of a plant which bears the flowers when it is depressed in its developement; so that, instead of being elongated into a rachis, it forms a flattened area, over which the flowers are arranged, as in *Compositæ*. There is thus the receptacle of flowers, which is the *clinanthium*; the receptacle of fruits, which is the *torus*; and the receptacle of ovules, which is the *placenta*.

The part of the vein to which the spore-cases of ferns are attached is also called a *receptacle*; whether it be exserted, as in *Trichomanes*, or dorsal, as in *Polypodium*.

Receptacles of Oil. In Botany, the name applied to those cysts which occur in the cellular tissue of plants, and contain an oily secretion, as in the dotted leaves of the Orange.

Receptacles of Secretion. In Botany, the cavities formed in the interior of plants into which the natural secretions drain.

Recess of the Empire. In History, the name given in judicial language to the decrees of the German diet. They are thought to have been so termed from being pronounced at the time when the diet was about to *recede* or separate. [DIET.]

Recession of the Equinoxes. [PRECESSION.]

Rechabites. A religious order among the ancient Jews, instituted by Jonadab, the son of Rechab, who charged them to abstain from wine, from building houses, and from planting vines. These rules were observed by the Rechabites with great strictness. (Jer. xxxv. 6.) In recent times, a branch of the body called *teetotallers* has assumed the name of Rechabites.

Recipe (Lat.). The symbol ℞ at the head of a medical prescription generally means *recipe*, or 'take.' Dr. Paris says this character is a relic of the astrological symbol of Jupiter, a planet under the ascendency of which herbs were often collected or prepared. (*Pharmacologia*.)

Reciprocal (Lat. reciprocus). In Arithmetic, the quotient resulting from the division of unity by any number. Thus, $\frac{1}{2}$ is the reciprocal of 2; and, conversely, 2 is the reciprocal of $\frac{1}{2}$.

Reciprocal Equations. A reciprocal equation is one which remains virtually unaltered when the unknown quantity is replaced by its reciprocal. Thus in order that the equation $F(x)=0$ of the n^{th} degree may be a reciprocal one, the following relation, where A is some constant, must be identically satisfied—

$$F(x)=Ax^nF\left(\frac{1}{x}\right).$$

From this we conclude that in reciprocal equations the coefficients of terms equidistant

from the extremities must be *numerically* equal. These coefficients, however, may be effected with like or unlike signs, and thus two classes of reciprocal equations must be distinguished. A reciprocal equation of odd degree has necessarily a root equal to -1 or $+1$, as it belongs to the first or to the second class; these roots being equal to their own reciprocals. A reciprocal equation of the second class can have no middle term, when its degree is even, since terms equidistant from the extremities have equal and opposite values; it has, however, -1 as well as $+1$ for roots. This being the case, it will readily be understood that *every reciprocal equation can be depressed* by division by $x+1$, $x-1$, or x^2-1, *to a reciprocal equation of the first class and of even degree*; i.e. to one whose terms, equidistant from the extremities, have coefficients equal in magnitude and sign. This latter equation may be also depressed, by one half, by the substitution $x+\frac{1}{x}=y$, and any value of y being found, the corresponding two values of x will merely require the solution of the quadratic $x^2-yx+1=0$, which is itself reciprocal. Hence we may say that the solution of a reciprocal equation of odd degree $2m+1$ may always be reduced to that of an ordinary equation of the m^{th} degree, whilst the solution of one of even degree $2m$ may be made to depend upon that of an equation of the m^{th} or $(m-1)^{th}$ degree, accordingly as the given equation belongs to the first or to the second class.

The binomial equations

$$x^n+1=0 \text{ and } x^n-1=0$$

are clearly reciprocal. The depressed equation in y upon whose solution that of the given equation depends will here have all its roots real. [ROOTS OF UNITY.]

Reciprocal Lines. In Statics, the lines of action of any two forces mechanically equivalent to a given system of forces. [FORCES, COMPOSITION AND RESOLUTION OF.]

Reciprocal Polars. Two curves S and S′ are said to be *reciprocal polars* when each tangent of the one is the polar with respect to any *auxiliary conic* Σ of a point on the other. The reciprocity here assumed results from the fundamental property of poles and polars, in virtue of which the polars of all points in a line pass through the pole of that line, and the poles of all lines through a point lie in the polar of that point. [POLES AND POLARS.] From this it follows that if S′ be the locus of the poles of the tangents of S, the latter will necessarily have the same relation to the former; for the tangent of S′ joining two consecutive points will necessarily have for its pole the point on S which is the intersection of the corresponding consecutive tangents or polars of these consecutive points. The consideration of the properties of polar reciprocals enables us to double all purely graphical (and even many metrical) properties of curves. The *method of reciprocal polars*, by means of which this is done, was first systematically employed by Poncelet (Crelle's *Journal*, t. iv.); it is an application or illustration of the great *principle of duality* which obtains in all geometrical theorems. Of two reciprocal polars the order and class of the one are respectively equal to the class and order of the other. For if m points of C lie in a line, m tangents of C′ pass through a point. One curve will have as many multiple tangents as the other has multiple points, and the order of multiplicity will be the same in both. To a stationary point on one will correspond a stationary tangent on the other, and to the cuspidal tangent will correspond the point of inflexion. Thus from the fact that a curve of the m^{th} order with δ double points and κ cusps is of the class

$$n=m(m-1)-2\delta-3\kappa$$

[POLES AND POLARS], we may conclude that a curve of the n^{th} class with τ double, and ι stationary tangents, is of the order

$$m=n(n-1)-2\tau-3\iota.$$

Thus two of Plücker's well-known equations are at once deducible from the other two. [SINGULARITIES OF CURVES.]

Reciprocal polar surfaces are similarly defined, one being the locus of the poles of all tangent planes of the other with respect to an auxiliary quadric surface. The properties of such curves and surfaces are discussed in most modern text-books; most fully, however, in the works of Poncelet, Chasles, Steiner, and Salmon. When the auxiliary quadric is a circle or sphere, one of the reciprocal polars is usually termed the *polar reciprocal*, or simply the *reciprocal* of the other.

Reciprocal Proportion. The relation which exists between four magnitudes such that, taken in order, the first has to the second the same ratio which the fourth has to the third, or the first has to the second the same ratio which the reciprocal of the third has to the reciprocal of the fourth.

Reciprocal Spiral. [HYPERBOLIC SPIRAL.]

Reciprocant of a Quantic. The tact-invariant of the system composed of that quantic and $x\xi+y\eta+$&c. . . It is also a contravariant of the quantic. [CONTRAVARIANT.] Geometrically, the reciprocant is synonymous with the polar reciprocal. [POLAR RECIPROCAL.]

Reciprocity (Lat. reciprocus, *alternating*). In Political Science, the term usually applied to the principle of securing, in commercial treaties between nations, mutual advantages to the same extent, e.g. the admission, mutually, of certain goods, supposed to be practically equivalent to each other, duty free, or at equal duties on importation. This principle is clearly different from that by which one nation seeks to impose the receipt of its own productions by another state on better terms than those on which it receives the productions of the latter; which was at one time considered a great stroke of diplomatic wisdom. But it is

equally different from (though it may be combined with) that of mere free trade. A nation, renouncing for itself the practice of imposing any differential duties whatever, either in favour of its own produce, or that of one nation as against another, has in reality no *reciprocity*, strictly so called, to which it may lay claim; although it will, of course, be its interest to induce other nations, by treaty stipulations as well as other means, to waive *their* differential duties. A treaty such as that of Mr. Gladstone's with France cannot in strictness be described as grounded on *reciprocity* principles, these being used only as auxiliary to a greater and more general purpose. [TREATY.]

Recitative (Ital. recitativo, from Lat. recitare, *to recite*). In Music, a species of singing having some resemblance to ordinary reciting. It is used in operas, &c. to express some action or passion, or to relate a story, or reveal a secret or design; and though written in true time, the performer may alter the parts of the measure as he thinks most suitable to produce certain effects, those that accompany him being dependent on his pleasure. The use of recitative was suggested in 1594 by Ottavio Rinuccini. (Hallam, *Literary History*, part ii. ch. vi. § 5.)

Reckoning (A.-Sax. recan, Ger. rechnen). In Navigation, the estimated place of a ship, calculated from the rate as determined by the log, and the course as determined by the compass, the place from which the vessel started being known. *Dead reckoning* means the same as *reckoning*, due allowance being made for drift, lee-way, currents, &c.

Reclinate (Lat. reclinatus, *turned backwards*). In Botany, bent down on some other part. The term is applied to parts which fall gradually from the perpendicular, as the branches of many trees or shrubs.

Reclination (Lat. reclino, *I bend back*). In Dialling, the angle which the plane of the dial makes with a vertical plane which it intersects in a horizontal line.

Recluse. The common title of a class of religious persons in Roman Catholic countries. [INCLUSI.]

Recognisance. In Law, an acknowledgement of a debt upon record. By a fiction of law, the obligation which a party enters into before a court of record or magistrate duly authorised, with condition to do some particular act—as to appear at the assizes, keep the peace, &c.—is in the form of a recognisance; the party acknowledging himself to be indebted to the crown, the plaintiff, &c., with condition that the obligation shall be void on performance of the thing stipulated.

Recoil (Fr. recul). In Artillery, the motion of a piece of ordnance or small-arm in a direction opposite to that in which the projectile is thrown. It is caused by the pressure of the gas upon the bottom of the bore, in the direction of the axis, equal to that which acts upon the projectile. It exerts a very destructive effect upon the gun-carriage.

Reconnaissance (Fr.). The term applied to the examination of the features of a country or the position of troops, with a view to military movements, such as the march of troops from one station to another, without reference to an enemy; the advance upon ground occupied by an enemy whom it is intended to force; the retreat before an enemy; or the taking up a position for defence. An officer sent on a reconnaissance should always make a sketch, and for this purpose he should be able to sketch rapidly, accurately, and clearly, by means of the eye and hand, unaided by instruments, the chief features of the country or position reconnoitred.

Record (Lat. recordor, *I call to mind*). Literally, an authentic account of any fact or transaction in writing, contained in rolls of parchment, wood, or any other durable substance, and preserved in a court of record. [ARCHIVES.]

RECORD. In Law, the authentic testimony in writing, contained in rolls of parchment, of the judgment of a superior court, and of the other proceedings in a case. Records are said to be of three kinds: judicial records; ministerial records on oath, being offices or inquisitions found; records made by conveyance or consent, as fines, recoveries, or deeds enrolled. [COURT.] Trial by record is used where a matter of record is pleaded in any action, as a fine, judgment, &c.; and the opposite party pleads *nul tiel record*, that there is no such record existing. On this issue is joined, which can be tried only by inspection of the record.

The public records of the kingdom are now under the superintendence of the Master of the Rolls. A public record office has been established, and arrangements have been made for the more convenient custody, arrangement, and inspection of the records.

Recordari Facias Loquelam (Lat.). In Law, a writ to remove proceedings out of an inferior court to the Queen's Bench or Common Pleas. It is now obsolete.

Recorder. The chief judicial officer of a borough or city exercising within it the jurisdiction of a court of record, whence his title has been said to be derived, though it seems likely that the term was anciently applied to any person present at a judicial proceeding and to whose remembrance or record of what had taken place the law gave credit in respect of his personal or official dignity. The jurisdiction of recorders was formerly of varying extent, but it has been remodelled and rendered uniform by the Municipal Corporations Act (5 & 6 Wm. IV. c. 76) and subsequent statutes in all cities and boroughs to which those Acts extend, and abolished in places of minor importance. In criminal matters it is now, in general, equal, within its area, to that of the quarter sessions of a county; in civil matters it has been for the most part superseded by the modern county courts. Recorders were formerly chosen without restriction by the corporations with which they were connected; but by the existing muni-

cipal system, the appointment is vested in the crown, and the selection is confined to barristers of a certain standing. The city of London is not affected by the municipal corporation Acts, and the recorder there is still elected by the court of aldermen, and his jurisdiction and duties are regulated by custom.

RECORDER. The name of a musical instrument, somewhat resembling the flageolet, formerly in use in this country. It had a peculiarly pleasing tone; hence Milton speaks of

—— The Dorian mood
Of flutes and soft recorders.

Recovery or Common Recovery. In Law, a mode of assurance in the form of a fictitious action, by means of which conveyances were made by various tenants possessed of limited rights in real property (more particularly by tenants in tail). It was formerly the usual means by which the entail of a landed estate was barred or cut off; but by stat. 3 & 4 Wm. IV. c. 74 common recoveries are abolished, and a new mode of conveyance for the use of tenant in tail substituted for them, to the great improvement of the law. [FEE TAIL.]

Recruit (Fr. recruter, Ital. reclutare, *to recruit*). A soldier is so called from the time of his enlistment till he has completed his course of drill. In order to obtain recruits for the army, the United Kingdom is divided into districts in charge of recruiting officers, the actual enlistment of recruits being carried on by non-commissioned officers under them. Acceptance of a shilling from a recruiting sergeant as an earnest of the queen's bounty constitutes an act of enlistment, but the recruit cannot be attested before a magistrate till twenty-four hours have elapsed from his enlistment, nor after a longer time than ninety-six hours. The present system of obtaining recruits at the public-house, and too often by aid of the excitement caused by strong drink, tends to bring a bad class of men into the service, many of whom afterwards desert, or are constantly committing offences against discipline; and it would probably be far greater economy to add to the inducements to remain in the army, and so draw to it a better class of men.

Rectangle. In Geometry, a right-angled parallelogram. When the adjacent sides are equal, it becomes a *square*. The area of a rectangle is numerically expressed by the product of the two numbers which express the lengths of its adjacent sides, and hence the term *rectangle* is sometimes, but incorrectly, used for *product*.

Rectangular. A term synonymous with right-angled. Thus *rectangular co-ordinates* denote co-ordinates which are referred to axes at right angles to each other. A *rectangular parallelopiped* is one whose plane angles are all right angles.

Rectification (Lat. rectus, *straight*, and facere, *to make*). In Geometry, the determination of a straight line, whose length is equal to that of the arc of a curve. The problem requires the integral calculus. If the curve be entirely in one plane, the length of the arc is $\int\sqrt{dy^2+dx^2}$; or if it be a curve of double curvature, its length is $\int\sqrt{dx^2+dy^2+dz^2}$. In both cases the equations to the curve usually enable us to express the differentials in terms of a single independent variable and its differential, and thus to prepare the expression for integration.

It will, however, very rarely happen that the rectification can be obtained in finite terms, as the substitutions generally introduce radical expressions under the symbol of integration, which are hardly ever so connected with the rational parts as to be susceptible of finite integration; hence it has been an object with mathematicians to transform the expressions into others, the successive terms of which are so related as to diminish at a very rapid rate. In this case, the approximation to the value of the arc is rendered comparatively easy. The first curve which was rectified was the semicubical parabola; and the merit belongs to Wm. Neil, whose rectification was published in 1657. Two years later the same curve was rectified by Van Heureat, in Holland.

RECTIFICATION. A Chemical term, generally implying a second or more frequently repeated distillation; thus, *rectified spirit of wine* means spirit which has been redistilled, and by which it is to a great extent freed from water, or rendered stronger.

Rectification of the Circle. [QUADRATURE.]

Rectifying Plane, Line, and Surface. The plane through the tangent of a non-plane curve which is perpendicular to the osculating plane is called the *rectifying plane*; it is manifestly at right angles to the normal plane as well as to the principal normal, and consequently contains the binormal. Two consecutive rectifying planes intersect in the *rectifying line*, which is the generator of the *rectifying* (*developable*) *surface* enveloped by all such planes. The rectifying surface plays an important part in the theory of non-plane curves. It was first introduced into the theory of such curves by Lancret. (*Mémoires des Savans Étrangers*, t. i. 1805.) The cuspidal edge of the rectifying developable is sometimes called the *rectifying edge*; its angle of torsion, being the angle between two consecutive rectifying planes, is equal to the angle of total curvature of the original curve, i.e. to the angle between two consecutive principal normals, to both of which latter the rectifying line is perpendicular. The primitive curve is a geodesic line on the rectifying developable, since the principal normal through which its osculating plane passes is also a normal to the surface. By unfolding the rectifying developable, therefore, the curve will become transformed to a right line. It is to this property that the rectifying surface owes its name. The rectifying surface is the *surface of centres* of greatest curvature of the develop-

able osculatrix [CURVATURE], for the rectifying plane is clearly a principal normal plane of this surface, so that any two consecutive normals of the latter, if they intersect at all, must do so in the rectifying line of the curve. The latter is consequently the axis of the osculating right cone of the developable osculatrix or of the curve itself. [OSCULATING RIGHT CONE.] The rectifying line is parallel to the shortest distance between two consecutive principal normals; hence the plane of a rectifying line and the corresponding principal normal cuts the consecutive principal normal in a point of the line of striction on the skew surface formed by these normals. But this plane is obviously a principal normal plane of the rectifying developable itself, so that the line of striction of the skew surface of principal normals lies on the surface of centres of curvature of the rectifying developable. For other properties of the rectifying surface, the reader is referred to the works cited under the term CURVE.

Rectilineal or Rectilinear Figure. In Geometry, a figure bounded by straight lines.

Rector (Lat. rector ecclesiæ, *ruler of the church*). Properly, the person or parson who has the charge and care of a parish church. In many parishes, however, before the Reformation, the great tithes [TITHES] had been appropriated by religious societies, who appointed a vicar (*vicarius*), usually one of their own body, to perform the services, leaving him the small tithes as his remuneration; and the greater and smaller tithes thus came to be distinguished as *rectorial* and *vicarial* respectively, and the term *rector* to be appropriated to the owner of the great tithes of a parish, whether the parson or some other person or body corporate. [IMPROPRIATION.] The rector, whether lay or clerical, is bound to repair the chancel of the church, leaving the nave to the care of the parishioners.

The term *rector* is also employed in Scotland to designate the head master of a public school or academy.

Rectrices (Lat. rectrix, *one who rules* or *guides*). The name of the tail-feathers of a bird, which, like a rudder, direct its flight.

Rectum (Lat. *straight*). The last portion of the large intestines; so named from an erroneous notion of the old anatomists that it was straight.

Recumbent (Lat. recumbo, *I lie down*). In Zoology, when a part is leaning or reposing upon anything.

Recurrent Nerves. Two branches of nerves from the *par vagum*, in the cavity of the thorax, are so called; they are distributed to the muscles of the larynx and pharynx.

Recurring Decimal. [CIRCULATING OR RECURRING DECIMAL.]

Recurring Continued Fraction. A continued fraction in which one or more quotients continually recur. [CONTINUED FRACTION.] It is sometimes called a *periodic continued fraction*.

Recurring Series. A series, two or more of whose consecutive terms are always connected by a given constant relation. The recurrence, it will be observed, is in the *law* which governs the formation of the series, and not in the *terms* of the latter. The term *recurring series*, however, is usually restricted to a series of the form

$$a_0 + a_1 x + a_2 x^2 + \&c. \ldots$$

where the coefficients a_n, a_{n-1} &c. of $k+1$ successive terms satisfy a given *linear* relation of the form

$$a_n + A_1 a_{n-1} + A_2 a_{n-2} \ldots\ldots + A_k a_{n-k} = 0.$$

Such a series is further said to be a *recurring series of the k^{th} order*, since each term is manifestly a linear function of the k preceding terms. The last equation expresses the *law of recurrence* of the series, and the expression

$$1 + A_1 x + A_2 x^2 + \ \ldots\ A_k x_k,$$

formed from it in a sufficiently obvious manner, is termed the *scale of relation* of the series. Every rational fraction of the form

$$\frac{f(x)}{F(x)},$$

where $F(x)$ exceeds $f(x)$ in degree, can be at once developed in a recurring series of which $F(x)$ will be the scale of relation, and conversely the generating fraction of a given recurring series will have its scale of relation for denominator; the numerator may easily be determined, by the method of indeterminate coefficients. The general term of recurring series may always be found when the linear factors of the scale of relation can be determined. In most text-books on algebra, these methods are fully described.

Recurvate (Lat. recurvatus, *crooked*). In Botany, this term is applied to parts which are bent back, but not rolled back as when revolute.

Recusants (Lat. recuso, *I refuse*). In English History, a term applied to those who refused to acknowledge the king's supremacy as head of the church. Of these the greater number were Roman Catholics.

Red. [CHROMATICS.]

Red Book. The name given to a book containing the names of all persons in the service of the state. The *Red Book of the Exchequer* is an ancient record, in which are registered the names of all who held lands per baroniam in the time of Henry II.

Red Copper-ore. Native dioxide of copper, or Cu_2O, containing 88·8 per cent. of copper and 11·2 per cent. of oxygen. It is of a deep red colour, which usually can only be seen by transmitted light. The variety crystallising in the octahedral form is called Cuprite; a lighter red fibrous variety is called Chalcotrichite, or Plush Copper-ore; while the massive or earthy kind is known as Brick or Tile Ore (Ziegelerz). It occurs in almost all copper mines among the gossans or oxidised portions of the lodes near the surface, especially in Cornwall and South Australia. The finest sin-

gle crystals were formerly obtained at Chessy near Lyons.

Red Fire. A pyrotechnical compound which burns with a beautiful red or pink flame. It consists of nitrate of strontia, mixed with charcoal and a little sulphur and chlorate of potassa.

Red Iron-ore. A name under which are included those varieties of Hæmatite which have a non-metallic or submetallic lustre.

Red Lead. An oxide intermediate between the protoxide and peroxide of lead. [LEAD; MINIUM.]

Red Lead-ore or **Crocoisite.** Native monochromate of lead; composed, when pure, of 31·3 per cent. of chromic acid and 68·7 oxide of lead. It occurs massive and crystallised of various tints of hyacinth-red, in Siberia, Brazil, Hungary, &c. The artificial salt is used as a pigment, but the colour has the disadvantage of not being permanent.

Red Marl. The name given to a portion of the Triassic series in England. [GEOLOGY.]

Red Precipitate. The peroxide of mercury, obtained by the decomposition of nitrate of mercury by heat. [MERCURY.]

Red Sea. This long, narrow, but deep channel between Arabia and Africa is separated from the Mediterranean only by the narrow and low isthmus of Suez, and connects with the Indian Ocean by the still narrower straits of Bab-el-Mandeb. It is remarkable for the desolate regions adjoining the bare volcanic rock on its shores and bottom, and the high temperature of its waters, which rapidly increases from Suez towards the straits until it amounts to upwards of 84°. This is only two or three degrees below the temperature of the oceanic warmth equator of the Pacific, and is the more trying to travellers because the sea is narrow and not exposed to any cooling winds. The navigation of the Red Sea is dangerous, and there are many coral reefs as well as much volcanic rock. [SUEZ CANAL.]

Red Silver-ore. [PROUSTITE; PYRARGYRITE.]

Red Snow. The common name of *Protococcus nivalis*, a minute alga, which in an incredibly short space of time produces large patches of a brilliant scarlet on the surface of snow in Arctic or Alpine regions.

Red Wood. The name of an Indian dyewood, obtained from *Pterocarpus Santalinus*. The Red Wood of the Turks is the wood *Cornus mascula*; that of the Bahamas comes from *Ceanothus colubrinus*; that of Jamaica, from *Gordonia Hæmatoxylon*; and that of the timber trade from *Sequoia sempervirens*.

Redan (Fr.). In Field Fortification, a work consisting of two faces, forming a salient angle. A *double redan* is composed of two redans joined together, thus forming a re-entering angle for mutual defence. [FORTIFICATION.]

Reddendum (Lat. *to be restored*). In Law, the technical term for a clause reserving rent which in a lease usually begins with the words *Yielding and paying*, &c.

Reddle (from *red*). A soft argillaceous peroxide of iron, occurring in opaque compact masses of various shades of light brownish-red, which sometimes passes into nearly brick-red. The best specimens, used for crayons, are brought from Germany; the common kinds, used for marking sheep and for coarse paints, are procured in large quantities from the carboniferous limestone of the Mendip Hills in Somersetshire, from the Forest of Dean in Gloucestershire, and Wastwater in Cumberland, as well as at Brixham and other places in Devonshire from Devonian limestone. The Reddle found at Rotherham in Yorkshire is the best material known for polishing optical glasses.

Redemptorists. A religious order founded in Naples by Liguori in 1732, and revived in Austria in 1820. They are bound by the usual monastic vows, and devote themselves to the education of youth. They style themselves members of the order of the Holy Redeemer, whence their name; but they are also often called *Liguorists*, from the name of their founder.

Redoubt, more correctly **Redout** (Fr. redoute, Ital. ridotto). In Fortification, an enclosed work, without flanking defence from its own parapets. [FORTIFICATION.]

Redruthite. A name given by Brooke and Miller to Copper Glance, magnificent crystallised specimens of which have been obtained from the mines near Redruth in Cornwall.

Reducing Scale. A scale used by surveyors for turning links into roods and acres by inspection.

Reductio ad Absurdum. [ABSURDUM.]

Reduction. The process of separating a metal out of a metallic oxide, sulphide, &c. In some cases this is effected simply by heat, but generally by the joint action of heat and some deoxidising agent; upon the large scale, charcoal, coke, or coal is almost always resorted to. [SMELTING.]

REDUCTION. In Arithmetic, the changing of quantities from one denomination to another.

Reduction of Figures. In Practical Geometry, the description of figures similar to given ones, but of different (generally smaller) dimensions. The pentagraph and the proportional compasses are the readiest and most accurate methods of performing these reductions; but in the absence of these, many different methods are taught in works of practical geometry.

Reduction, Formulæ of. In the Integral Calculus, formulæ which serve to reduce given integrals to others of simpler forms. The following are useful examples of such formulæ:

$$\int x^{m-1}(a+bx^n)^p = \frac{x^m(a+bx^n)^p}{m} - \frac{npb}{m}\int x^{m+n-1}(a+bx^n)^{p-1}\,dx$$

$$\int \sin^p x \cos^q x\,dx = \frac{\sin^{p+1}x\cos^{q-1}x}{p+1} + \frac{q-1}{p+1}\int \sin^{p+2}x\cos^{q-2}x\,dx.$$

Definite integrals may often be greatly simplified by such formulæ, which are obviously deduced from the method of *integration by parts*. [INTEGRAL CALCULUS.]

Redundant Hyperbola. A line of the third order, having three pairs of asymptotic branches. Its properties may be seen in Newton's *Enumeratio*.

Redwing. [TURDUS.]

Reed (A.-Sax. hreod, Ger. ried). The common name for *Phragmites communis*, a waterside native plant widely distributed in other countries, and which was formerly (and is still by some) included in the genus *Arundo*. The name is applied also to other plants. Thus the Small-reed is *Calamagrostis*; the Aromatic-reed of Scripture is *Andropogon Calamus aromaticus*; the Egyptian-reed is *Papyrus antiquorum*, &c.

REED. In Music, a thin tongue of wood or metal (formerly made actually from a reed), which, being set in vibration by the action of wind, gives the sound to certain musical instruments, as the oboe, the clarionet, and the bassoon; as also in certain stops of the organ, in the harmonium, and the concertina. Sometimes the reed beats against its seat, and sometimes it is free, the latter variety being called the free reed.

Reef. A chain of rocks in the ocean lying near the surface. Coral reefs are reefs of coral brought close to the surface of the sea without rising much above the surface. [PHYSICAL GEOGRAPHY.]

REEF. In Navigation, *to reef* is to diminish the surface of the sails on the increasing of the wind. Sails attached to yards are reefed at the head. Strong horizontal bands of canvas, from three to six feet apart, extend across the sails; these are called *reef bands*, there are usually four in each topsail, and two in the foresail and mainsail. The reef band is commonly pierced with two holes in each cloth (or breadth of canvas) in the sail; through each hole are drawn two *reef points*—short pieces of flat rope, each having an eye in one end, and hung one before and the other abaft the sail, each passing through the eye in the end of the other. The sail being lowered and trimmed to the wind so as to shake, the extremities of the reef band are drawn up towards the *yard arm* by the ropes called *reef tackles*. The men then going out upon the yard, which they lean over while their feet are supported by the *foot ropes*, gather up the loose canvas of the sail till they reach the reef band, which they keep extended tight along the yard until the *earings* are *passed* or secured, the weather earing being passed first; they then tie the two reef points of each pair together over the yard, and the sail is reefed, the surface having been thus diminished by the depth of one reef. Gaff sails are reefed at the foot. The sail being lowered enough to slack the canvas, the earing on the after leech is brought or hove down to the boom end by a strong rope called a *reef pendant*; the men then standing wherever they can reach the foot of the sail, tie the points under it. When the yard is not lowered, as in reefing the courses, the sail is partly clued up for reefing.

Under Cunningham's patent, sails may be reefed or furled by ropes from the deck; an improvement of great importance, as reefing sails during tempestuous weather is attended with considerable danger to life. The action of this apparatus will be described under SAILS.

Reel (A.-Sax. reol). An angler's implement attached to the butt of the rod, for the purpose of winding in the line when a fish is hooked. The barrel of the reel should be of sufficient diameter to wind in quickly, as a fish is often lost from the inability of the angler to bring him rapidly within reach of the landing net; especially where, as in fly fishing, a great length of line has been thrown out.

REEL. A lively dance peculiar to Scotland, generally written in common time of four crotchets in a bar, but sometimes in gig time of six quavers.

Reeming Iron (Lat. rima, *a chink*). An iron wedge of very acute angle used by caulkers in forcing slightly apart the planks of a ship, in order that oakum may be driven between.

Reepers. Laths split from the stems of the Palmyra Palm, and used in the East for building purposes.

Reeve (A.-Sax. gerefa, *an officer* or *governor*). A word of very general application, entering into the composition of some titles yet in use. Hence *sheriff*, i.e. *shire-reeve*, the governor of a shire or county; *borough-reeve*, *port-reeve*, &c.

REEVE. In Ornithology. [RUFF.]

REEVE. The Sea term for passing a rope through any block or hole through which it is intended to run.

REEVE. In Zoology. [MACHETES.]

Reeving Tackle. Passing the ropes through the blocks in a system of pulleys.

Refection (Lat. refectio, from reficio, *I restore*). In the language of Ecclesiastical communities, a spare meal, sufficient only to maintain life; whence the hall in convents where meals are taken is termed *refectory*.

Refectory. [REFECTION.]

References (Lat. refero, *I bring back*). In Printing, marks carrying the eye from the text to the marginal or foot note. The most common are the *, †, ‡, §, ‖, ¶; but where there are more than six notes in a page, the neatest mode is to print small letters (^{a}) or figures (^{1}).

Referendaries (from Lat. referendus, *to be referred*). In the early monarchies of Europe after the fifth century, public officers charged with the duty of procuring, executing, and despatching diplomas and charters. The office of great referendary, in the French monarchy, became merged in that of chancellor.

Refikite. A mineral hydrocarbon forming tubercles and small veins of a wax-white colour, in Lignite, at the Abruzzi near Naples. Named after Refik Bey. Analogous to paraffine.

Refining. The process of separating gold from silver and copper. For this purpose the alloy is first melted and granulated by being poured in a fused condition into water. Between 200 and 300 kilogrammes of the granulated alloy are boiled in concentrated sulphuric acid in vessels of cast iron or platinum. The silver and copper of the alloy are thus converted into sulphates, the gold being unattacked. During this ebullition large quantities of sulphurous acid are evolved, which are conducted into the leaden chambers of the sulphuric acid factory, and there recovered in the form of sulphuric acid, which may be used for subsequent operations. When the ebullition with sulphuric acid is complete, i. e. after two or three hours, the mixture is allowed to stand for a short time, and the liquid poured off from the sediment of spongy gold. The mass is then washed with water, the washings being added to the liquid previously poured off, and the gold boiled once more with sulphuric acid. Even after this treatment the metal is not absolutely pure, but contains about 0·5 per cent. of silver, which may be removed by fusion with acid sulphate of soda. After the second ebullition with sulphuric acid, the gold is well washed with water, dried, and fused. The solution containing the sulphates of silver and copper is mixed with water, and gently heated with metallic copper. By this means the silver is precipitated, an equivalent quantity of copper passing into solution in the form of sulphate. The spongy silver is then separated from the excess of copper, well washed, dried, pressed by hydraulic power, and fused.

The solution of sulphate of copper is now evaporated to crystallisation, and the mother liquors, which contain large quantities of sulphuric acid, are employed in a future operation for the treatment of the original alloy.

For this process, which is termed the *parting of gold*, it is necessary that the alloy should not contain more than 20 per cent. of gold; otherwise the excess of gold protects the silver and copper from the action of the acid.

In cases in which the alloy is richer in gold, it is previously fused with a sufficient quantity of auriferous silver.

Alloys containing small quantities of gold and silver are first roasted, the oxide of copper formed in this manner being removed by means of dilute sulphuric acid, and the residue treated in the usual way.

Alloys containing as little as 0·05 per cent. of gold may be economically worked by this process of parting. Refined gold contains about $\frac{992}{1000}$ of pure gold.

Another process of gold refining, termed *quartation*, consists in fusing the alloy with three times its weight of silver, and boiling the granulated product with nitric acid, which removes the silver, leaving the gold in a porous condition. This process was at one time almost universally adopted for the refining of gold, but the low price of sulphuric acid renders the operation of parting the more economical one for use on a large scale.

The term *refining* is also applied to the purification on a manufacturing scale of other metals; of salts, as nitre and common salt; and of other bodies, as sugar, &c.

Reflecting Circle. An astronomical instrument for the measurement of angles by reflection. [SEXTANT.] The term is also applied to a surveying instrument, invented by Sir Howard Douglas, which combines the advantages of Hadley's quadrant and the protractor. The object of it is to protract, or lay down on the plan, the angles measured with the instrument from the instrument itself, without any intermediate step, or even a register of their values. The advantage of such an instrument must be obvious in military surveys, where expedition is important, while accuracy is thereby far more efficiently insured than by the old and more tedious process. It is also advantageously used in forming general sketches of a country.

Reflector. The name generally given to a reflecting telescope. [REFLEXION; TELESCOPE.]

Reflex (Lat. reflexus, part. of reflecto, *I bend back*). In Painting, the illumination of one body, or a part of it, by light reflected from another body. The foundation of the law of *reflexes* depends upon the knowledge that every body in light reflects that light, to a certain degree, in the same way that flame does. The stronger, therefore, the light on the body, the stronger will be the *reflex*, distances being equal. Again, the more directly the light falls on a body, the more influence it will have in imparting a reflex.

Reflex Function. In Physiology. [AUTOMATIC; MOTORY; SENSORY.]

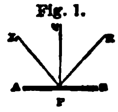
Reflex Zenith Tube. An instrument designed by the Astronomer Royal, and in use at the Greenwich Observatory, for measuring the zenith distances of stars very near the zenith. It consists mainly of an object-glass of 5 inches diameter and 10 ft. focal length; of a micrometer firmly attached to the cell of the object-glass; and of a trough of mercury placed beneath the object-glass at a distance of nearly half its focal length. The cell of the object-glass is fixed in a tube sliding in another tube fastened to the flooring of the small chamber in which the instrument is erected, the mercury being a short distance beneath the flooring. By this apparatus the parallel rays proceeding from a star very near the zenith are, while in a converging state, reflected from the mercury, so as actually to converge to a focus and form an image at a short distance above the object-glass; and it is ingeniously contrived that the point of convergence shall be in the same line (measured parallel to the diameter of the object-glass) with its focal centre. By this means any inaccuracy which would arise from a small error of level of the plane of the micrometer is avoided. A micrometer is mounted upon the cell which carries the object-glass, which has a series of

wires stretched across its side bars, and whose screw acts against the standards carrying the bars, the wires being placed at intervals nearly equivalent to double the distance of γ Draconis (the star which passes nearest to the zenith) from the zenith of Greenwich. For viewing the images of the star and the wires together, a compound 4-glass eye-piece is used, consisting of two distinct parts, the first part consisting of a first lens for receiving the rays from the object-glass, and a glass reflecting prism for turning them into a horizontal direction, the prism having one side ground to a spherical surface, so as to produce the effect of the second glass of the eye-piece, and to avoid unnecessary loss of light. This part is fixed in a tube carried between the bars of the micrometer. The second part consists of the third and fourth glasses of the eye-piece mounted in a tube carried horizontally by a fixed support, so as to allow the head of the observer to avoid interference with the rays after passing through the object-glass. The cell of the object-glass is made to revolve, carrying with it the micrometer, for the purpose of making observations in reversed positions. The micrometer is also double, carrying screws and divided heads on each side of the object-glass, and it is so arranged that by the action of one of the screws the micrometer wires are carried without disturbance of the reading of the head attached to the other screw.

Reflexion. In Mechanics, this word denotes the rebound or regressive motion of a body from the surface of another body against which it impinges. In Natural Philosophy, the term is applied to the analogous motions of light, heat, and sound, when turned from their course by an opposing surface. The laws of the reflexion of light form the branch of science called *catoptrics*; those of the reflexion of sound are sometimes called *cataphonics*. [SOUND.]

Reflexion of Light.—When we consider only the *direction* of the rays of light after being reflected from a polished surface, and leave its *quantity* or *intensity* out of view, the laws of reflexion are extremely simple. Suppose AB (fig. 1) to be a smooth polished surface, or mirror, and a ray of light proceeding in the direction LP to impinge on the surface at P, and to be reflected from it in the direction PR. Through the point P draw PQ a normal or perpendicular to the surface; then, adhering to the definitions adopted by most writers on optics, the angle LPQ is called *the angle of incidence*, QPR *the angle of reflexion*, the plane in which are the two straight lines LP and PQ is called *the plane of incidence*, and the plane determined by QP and PR *the plane of reflexion*. Now the two general laws of reflexion are these: 1st. The plane of reflexion coincides with the plane of incidence; or the three straight lines LP, PQ, and PR, are in one plane. 2nd. The angle of reflexion is equal to the angle of incidence, and on the opposite side of the normal. These laws

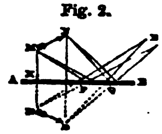
Fig. 1.



hold true, whatever be the nature of the reflecting surface, or the origin of the light which falls on it. Experience offers no exception to them whatever; and all the phenomena of reflection from mirrors or polished surfaces, whether plane or having any regular curvature, are readily deduced from them as simple geometrical consequences.

Reflexion from Plane Mirrors.—To determine the path of the reflected rays, and the formation of images by plane mirrors, suppose MN (fig. 2) to be an object placed before the plane reflecting surface AB, and the eye to be situated at E. The rays of light which proceed from the point M, and are reflected to the eye at E, will impinge on the mirror at P, and appear to come from a point m, which, in respect of the plane AB, is symmetrical with M; i. e. is placed in the straight line drawn from M perpendicular to the surface, and at the same distance from AB on the opposite side. For let MK be the perpendicular, and let it be continued till it meet the prolongation of EP in m: then, from the equality of the angles of incidence and reflexion, the angles MPK and EPB (which are the complements of those angles) are equal; hence $MPK = KPm$; and the two right-angled triangles KPM and KPm having also a common side, are every way equal; whence $Km = KM$. In like manner, the rays which issue from N, and are reflected to E, will appear to proceed from a point n symmetrical with N; and as the same thing is evidently true with respect to every other point of the object, a perfect image mn of the object will be formed on the opposite side of the mirror, and at the same distance. It will be observed that the image is not, properly speaking, reversed, like writing looked at through the opposite side of the paper: the spectator sees the same side of the object as if he stood in front of the mirror, and viewed the object directly; but, in the reflected image, right takes the place of left, and left of right.

Fig. 2.

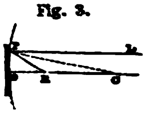


Reflexion from Curve Surfaces.—In order to apply the two general laws of reflexion to the determination of the direction of a ray reflected from a curve surface, it is assumed that the reflexion takes place at each point of the surface in the same manner as it would from a plane touching the curve surface at that point; and the problem therefore becomes that of determining the directions of the normal at the given point; for, when the directions of the incident ray, and of the normal at the point of incidence, are both known, the plane of the reflected ray, and the position of the ray in that plane, are both given. The mirror may be concave or convex; and the incident rays may be parallel or divergent.

Let D (fig. 3) be the centre of a concave mirror, DC its axis, C the centre of curvature at D; and assume the semidiameter of the mirror DP to be small in comparison of its

radius of curvature CD. Now suppose a ray of light LP, parallel to the axis, to fall on the mirror at P; then, if we draw PC, and make the angle CPR=CPL or PCD, PR will be the direction of the reflected ray; for, by the nature of curvature, CP is a normal to the surface, the arc DP being small. But, on the hypothesis of DP being small, we have also RP=RD; and by reason of the equal angles RPC and RCP, RP=RC, therefore RD=RC; or R is a given point, and, consequently, all the rays which fall on the mirror parallel to CD are reflected into the same point R. From this property the point R, which bisects the radius CD, is called *the principal focus* of the mirror, or *the focus of parallel rays.* [Focus.]

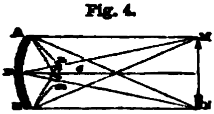
Fig. 3.



If the reflecting surface were a portion of a paraboloid, then all rays parallel to the axis would be accurately reflected into the focus at R, whatever the extent of the surface might be; but, on account of the practical difficulty of grinding and polishing curve surfaces of any other form than the spherical, the concave and convex mirrors required for optical purposes are often spherical.

From what has now been shown, it is easy to see in what manner images are formed by concave or convex mirrors. Let MN (fig. 4) be an object placed before a concave mirror AB, beyond its centre of curvature C. On tracing the path of the rays MA, MD, MB, after reflexion, they will all be found to meet in the point *m*, and those which proceed from N will in like manner be found to meet in *n*; whence rays diverging from every point of the object between M and N will meet, after reflexion, in a point situated between *m* and *n*: and in this manner an inverted image *mn* of the object will be formed. The magnitude of the image is to that of the object as D*m* to DM, or as the distance of the image from the mirror is to the distance of the object from the mirror; and the image will be more brilliant in proportion as the rays of light coming from the object are collected within a smaller space. If the object were placed at *mn*, then an enlarged image would be formed at MN. It is on this principle that reflecting microscopes and telescopes are constructed. [Microscope; Telescope.]

Fig. 4.



Intensity of reflected Light.—It has now been shown that the path of the reflected light can be determined in all cases with geometrical precision, when the form of the reflecting surface is known; but the case is very different when the question is to determine the quantity or proportion of the light which is thrown into a different direction by an opposing surface. The following laws, however, have been established by experiment: 1st. The quantity of light regularly reflected by non-metallic surfaces increases with the angle of incidence, but does not vanish entirely when that angle becomes 0. 2nd. In the case of metals the reflective power does not vary much with the angle of incidence, but it is greatest at small angles of incidence. 3rd. Bodies of different natures, placed in the same circumstances, reflect very different proportions of the incident light.

On this subject a great number of experiments were made by Bouguer, and more recently by Arago, Fresnel, Potter, and others. The following numerical relations are given by Bouguer: When a beam of light, the intensity of which is represented by 1000, falls upon water so as to make an angle of 0° 30′ with the surface, the intensity of the reflected light is represented by 721; at an angle of 15° with the surface, by 211; at an angle of 30°, by 65; and at an angle from 60° to 90°, by 18. Of 1000 rays falling upon a surface of glass, and making an angle of 5° with the surface, 543 are reflected; 300 when the angle is 15°; 112 when 30°; 25 when 60°, or above. Of 1,000 rays falling on a polished surface of black marble, 600 are reflected when the angle with the surface is 3° 15′; 156 when 15°; 51 when 30°; 23 when 60° and upwards. Silver surpasses all other metals in reflecting power. When the incidence is perpendicular, it reflects more than 900 rays per 1,000. (*Traité d'Optique.* See also the *Edinburgh Journal of Science* for 1830 and 1832.)

In order to produce reflexion in a greater or less degree, the only indispensable condition is, that light pass from one medium to another having a different refractive power. In passing through a perfectly homogeneous medium, no reflexion takes place; but whenever there is a change of medium (and this change may occur in the same substance by an inequality of density in the different parts, or a different arrangement of the particles), more or less reflexion takes place at the surface which separates the two media. Thus, in passing through the atmosphere, the solar light undergoes an infinite number of partial reflexions before it arrives at the earth, as every successive thin stratum of air, by reason of its increasing density, forms, as it were, a different medium. [Refraction, Astronomical.]

Bodies are visible only in consequence of rays irregularly reflected from their surfaces meeting the eye; for rays which are regularly reflected show only the luminous points from which they emanate, and not the surfaces on which they fall. If the lunar surface were as perfectly polished as a globule of pure mercury, the moon would present to us only a reflected image of the sun. [Light; Optics.]

Reform, Parliamentary. The changes effected in the House of Commons by the English, Scotch, and Irish Reform Acts of 1832 are specified under the head Parliament. The movement in favour of such reform began early in the reign of George III. In 1780, the duke of Richmond introduced in the House of Lords a measure of almost democratic character. This was followed (1783) by Mr. Pitt, whose

object was chiefly to emancipate the crown from the influence of the great families. No result, however, followed these attempts, and the change was effectually adjourned for many years by the French wars (1792 to 1815). In 1831, Lord John Russell brought in the English Reform Bill. It was negatived, and parliament dissolved by William IV. in April that year. The new parliament, which met in July, gave a decided majority to ministers. The measure passed the House of Commons in September. On October 7 the Lords threw it out. Early in the following year the contest was renewed, and the Lords finally gave way on the second reading, but renewed their opposition in committee. Ultimately they yielded to the threatening aspect of the country, and the pressure put on them by the suggestion of a new creation of peers; and the Reform Act passed on June 7, 1832. Measures for a still further extension of the franchise were introduced by the governments of Lord John Russell in 1852, of Lord Aberdeen in 1854, of Lord Derby in 1859, and of Lord Palmerston in 1860; but in each case failed or were withdrawn. For some years after 1860 the question appeared to excite little interest in parliament, but public attention was again directed to it during the general election of 1865, and in 1866 the government of Lord Russell introduced a bill for lowering the franchise, and later in the same session a bill for the redistribution of seats. The two bills were afterwards consolidated, but were not approved by the House, and their failure led to the resignation of the ministry. (Lord Russell, *English Government and Constitution*; Molesworth, *History of the Reform Bill.*)

Reformation (Lat. reformatio). An era in Political and Ecclesiastical History, when the doctrines and usages of the Roman church, then dominant throughout the Western states of Christendom, were first successfully called in question. This event is commonly dated from the year 1517, when Luther began to oppose the pope, and condemned the sale of indulgences. Mosheim assigns to it the date 1520, when Luther was excommunicated.

Prior to the Reformation, the pope claimed of divine right, and exercised, absolute authority over the whole Christian church, with the exception of those states and provinces in which the Eastern or Greek church was established. Not only was his authority regarded as supreme on subjects of doctrine and discipline, but his decisions were considered as infallible; and whoever ventured to question or gainsay them was liable to such canonical censures and temporal penalties as the canon law determined. The pope also laid claim to supremacy even in temporal things throughout the wide range of his religious authority; though the exercise of this supremacy was not always quietly submitted to, and was sometimes resisted with success. He regarded all parts of the world not inhabited by Christians as uninhabited, and parcelled out these countries to their Christian conquerors according to his sovereign pleasure. But while the absolutism claimed by the Roman pontiff was calculated to arouse jealousy and opposition, these feelings were greatly increased by other causes; such as the immoral lives of the clergy; the exorbitant wealth of the church; the great personal immunities of ecclesiastics, and their encroachments on the jurisdiction of the laity. These and similar circumstances, which the invention of the art of printing and the revival of learning had tended more thoroughly and widely to disclose, gradually prepared the public mind for a reformation.

According to the doctrine of the Roman church, all the good works of the saints, over and above those necessary for their own justification, are deposited, together with the infinite merits of Jesus Christ, in one inexhaustible treasury. The keys of this treasury were committed to St. Peter, and his successors the popes, who might, it was said, open it at pleasure, and by transferring a portion of this superabundant merit to any particular person for a sum of money, convey to him either the pardon of his own sins, or a release for anyone, in whose happiness he was interested, from the pains of purgatory. Hence the origin (which took place in the eleventh century) of the sale of *indulgences*. Pope Leo X., in order to raise contributions towards building the church of St. Peter at Rome, granted, in 1517, the right of promulgating those indulgences in Germany, together with a share in the profits arising from the sale of them, to the archbishop of Magdeburg. The archbishop employed, as his chief agent for retailing them in Saxony, one Tetzel, a Dominican friar, who assisted by the monks of his order executed the commission with great zeal, but with little discretion or decency; and, by disposing of them at a very low price, carried on for some time an extensive and lucrative traffic among the credulous and ignorant. The princes and nobles were irritated at seeing their vassals drained of their wealth to replenish the treasury of a profuse pontiff. Men of piety regretted equally the corruptions of the church and the delusions of the people. Even the most unthinking were shocked at the scandalous behaviour of Tetzel and his associates. But it was reserved for Martin Luther, a monk of the Augustine order, and at that time professor of theology at Wittenberg, effectually to expose the artifices of those who sold, and the simplicity of those who bought, indulgences. What motives first induced him to oppose this traffic cannot now be ascertained. It was not a novelty, as it had been practised throughout Christendom for several centuries. Some writers have imagined, though with what justice is not evident, that his opposition was founded in jealousy, because this gainful trade had not been conferred on the Augustinians, to whom he belonged, but on the Dominicans, a rival order. But whatever were his motives, his opposition at first was confined simply to the sale of indulgences.

His memorable theses, ninety-five in number, against this practice were affixed to the doors of the cathedral of Wittenberg, October 31, 1517; while from the pulpit he inveighed bitterly against the irregularities and vices of the monks who published indulgences, as well as against the abuse itself. The sentiments contained in his theses he proposed not as points fully established, or of undoubted certainty, but merely as subjects of enquiry and disputation; and to the whole he subjoined solemn protestations of his high respect for the apostolic see, and of his implicit obedience to its authority. No opponent appeared at the time prefixed. The theses spread over Germany with astonishing rapidity, and were everywhere read with the greatest avidity. Meanwhile Tetzel, in opposition to Luther, published counter-theses at Frankfort-on-the-Oder; and Eckius, a celebrated divine of Augsburg, endeavoured with others to refute Luther's notions. But this opposition was of little or no avail. Luther supported his views by arguments founded on reason or derived from Scripture, and his cause was found daily to gain strength.

Leo, naturally fond of ease and pleasure, paid little or no attention to the dispute that was thus raging in Germany, and at first despised it as a mere monkish squabble. But the tidings of Luther's rapid success, and the clamours of the ecclesiastics for aid and vengeance, at length roused him from his apathy. On August 21, 1518, he summoned Luther to appear at Rome, within sixty days, before the auditor of the chamber and the inquisitor-general, whom he empowered jointly to examine his doctrines and to decide concerning them. This was evidently an unjust tribunal; and through the influence of Frederick, the elector of Saxony, who was favourable to the new doctrines, and of others, the pope, having received a submissive letter from Luther himself, agreed to refer the hearing and determining of the cause to his legate in Germany, Cardinal Cajetan, a Dominican eminent for scholastic learning.

The reformer accordingly appeared before Cajetan, who, after some discussion, commanded him to retract his opinions; but Luther with his characteristic intrepidity declared that he could not, with a safe conscience, renounce opinions which he believed to be true, nor should any consideration induce him to do what would be so base in itself, and so offensive to God. The result was, that he was induced to withdraw secretly from Augsburg and return to Wittenberg; previously to which, however, he prepared a solemn appeal from the pope ill informed at that time concerning his cause, to the pope when he should be better able to judge respecting it. But so impatient were Luther's enemies at Rome, that even before the sixty days had expired he was there condemned as a heretic, Leo, in several of the briefs and letters, having stigmatised him as a child of iniquity, and as given up to a reprobate mind. But Luther was not to be deterred from teaching and promulgating his opinions both from the pulpit and through the press; and as every step taken by the court of Rome against him convinced him that Leo would soon proceed to the most violent measures, he had recourse to the only expedient in his power in order to prevent the effect of the papal censures. He appealed to a general council, which he affirmed to be the representative of the Catholic church, and superior in power to the pope, who, being a fallible man, might err, as St. Peter, the most perfect of all his predecessors, had erred. As the controversy advanced, Luther's views began to expand; and in his disputation with Eckius he went so far as to question the supremacy of the pope over the church, as well as the doctrines of purgatory, auricular confession, and absolution; and about the same time he published several treatises, in which he more openly expressed his dissent. Luther may now be said to have embraced the tenet which became henceforth the characteristic of his theology, namely, that Scripture is the only rule of faith and manners, and that this rule is to be interpreted by the exercise of private judgment. A step was at this period (June 1520) taken by the court of Rome fatal to the object which it had in view. The pope issued a bull condemning, as heretical and offensive to pious ears, forty-one propositions extracted out of Luther's works; all persons were forbidden to read his works on pain of excommunication; those who possessed a copy of them were commanded to commit it to the flames; and he himself, if he did not within sixty days publicly recant his errors and burn his works, was to be pronounced a heretic, excommunicated, and delivered over to Satan; all secular princes being required, under pain of incurring the same censure, to seize his person, that he might be punished as his crimes deserved.

This sentence excited more indignation than terror among the followers of Luther, and gave a fresh impulse to the spread of the new doctrines. In some cities the people violently obstructed the promulgation of the bull; in others, the persons who attempted to publish it were insulted, and the bull itself was torn in pieces and trodden under foot. Luther, after renewing his appeal to the general council, published remarks on the papal bull; and assuming a bolder tone, declared the pope to be that man of sin, or Antichrist, whose appearance is foretold in the New Testament. He declaimed against his tyranny and usurpations, and exhorted all Christian princes to shake off such an ignominious yoke. Nor did he stop here. As Leo had, in execution of the bull, appointed Luther's works to be burnt at Rome, the latter, by way of retaliation, assembled all the members of the university of Wittenberg, and with great pomp, in presence of a vast number of spectators, cast the volumes of the canon law, together with the bull of excommunication, into the flames; and his example was imitated in several cities of

Germany. This took place on the 10th of December, 1520; and on the 6th of the ensuing month the pope launched a second bull against him, by which Luther was finally expelled from the communion of the church. Thus separated from all connection with the see of Rome, Luther was enabled to attack with the greater success most of the peculiar papal doctrines, both theological and ecclesiastical; and thus laid the foundation of that reformation of religion which at first he never contemplated.

A spirit of enquiry having, by means of Luther's preaching and publications, and the procedure of the court of Rome, been excited in the public mind, the progress of the reformed doctrines was rapid and general, and threatened to embrace the whole of Germany, although the emperor Charles V. co-operated with the pope to check and destroy them. Luther, too, was protected, from various motives, not merely by the elector of Saxony, but by many other princes; and the new views were adopted and sedulously propagated by Melanchthon, Carlostadius, and other eminent men. Erasmus, too, though he did not long follow in the same course as the German reformer, and ultimately wrote against some of his views, yet discovered and exposed, with great learning and ability, many errors both in the doctrine and worship of the Roman church.

Under these circumstances was held the imperial diet at Worms (January 1521), to which the different princes were invited, in order to concert measures for checking the progress of the new doctrines which threatened to disturb the peace of Germany, and to overthrow the religion of their ancestors. An attempt to condemn him in his absence was frustrated by a majority of the members of the diet; and Luther, under a safe-conduct, was summoned to appear before them. He did not hesitate to attend; but neither threats nor entreaties could induce him to retract any of his opinions, or to consent to their being tried by any other rule than that of Scripture. He was allowed to leave the city in safety; but an edict was published in the emperor's name, after his departure, putting him under the ban of the empire. The circumstances, however, in which Charles was placed, the commotions in Spain, and the wars in Italy and the Low Countries, together with the prudent precaution of the elector of Saxony in concealing Luther in the castle of Wartburg, all concurred in preventing the edict being carried into effect. During his confinement his opinions continued to gain ground; and the Augustinians of Wittenberg ventured on an alteration in the established forms of public worship, by abolishing the celebration of private masses, and by giving the cup as well as the bread to the laity in administering the sacrament of the Lord's Supper. In a short time, however, the new views were condemned by the university of Paris, and a refutation of them was attempted by Henry VIII. of England. Luther published animadversions on both with as much virulence as if he had been dealing with an ordinary adversary.

Meanwhile an attack no less violent, occasioned by a similar cause, was made on the Roman church in Switzerland. The Franciscans being intrusted with the sale of indulgences in that country, executed their commission with the same indiscretion which had rendered the Dominicans odious in Germany. But they were met and opposed (1518) by Zuinglius, a man not inferior to Luther himself in zeal and intrepidity, and who advanced with perhaps more daring and rapid steps to overthrow the whole fabric of the established religion. Notwithstanding that the universities of Cologne and Louvain pronounced his doctrines to be erroneous, the cantons of Zurich, Berne, Basle, and Schaffhausen embraced his opinions. Several conferences were at different times held between the Roman Catholics and the *Evangelicals*, as the followers of Zuinglius were called; and all of them tended to the spread of the reformed faith. After a conference held at Berne in 1528, the council of that canton published ten theses, which embodied the substance of the Reformation in Switzerland.

The Swiss and the German reformers were at first unacquainted with the proceedings of each other, though both were animated by the same spirit. But, while they both resisted and exposed the usurpations and errors of the Roman church, and generally agreed in their sentiments, they entertained very different theological opinions; and thus were sown the seeds of those divisions which have since agitated the reformed churches. The chief subject of dispute between the two reformers was concerning the manner in which the body and blood of Christ were present in the Eucharist. Luther and his followers, though they rejected the papal belief of transubstantiation, were nevertheless of opinion that the body and blood of Christ were really present in the Lord's Supper, a doctrine repudiated by Zuinglius and his adherents. Both parties maintained their opinions with equal obstinacy; and as this dispute threatened to retard the great work of reformation, and to bring discredit on its adherents, the landgrave of Hesse invited Luther and Zuinglius to a conference at Marburg, in order to promote unanimity and peace. After a disputation of four days, however, neither of the contending parties could be persuaded to abandon their views. But as both agreed in their sentiments not only as to the popish hierarchy, but as to the fundamental principles of Christianity, they parted in Christian charity, though not in brotherhood, agreeing to refrain from open controversy.

The struggle between the Roman Catholics and the reformers still raged in Germany. At the diet of the empire held at Spires in 1526, the emperor's ambassadors used their utmost endeavours to suppress all disputes about religion, and insisted on the vigorous execution of the sentence which had been pronounced against

Luther and his followers at Worms. This attempt was successfully resisted by the majority of the members; and it was at last unanimously agreed to present an address to the emperor entreating him to call a general council without delay; and that the princes of the empire should in the meantime be allowed, in their respective dominions, to manage religious matters as they should think proper. These resolutions proved favourable to the cause of the Reformation. The war in which the emperor was at this time engaged with the pope gave a decided advantage to the friends of the reformed faith, and greatly increased their number. At a diet, however, held in the same place in 1529, the power which had been given to princes of managing ecclesiastical affairs until the meeting of a general council was revoked by a majority of votes, and every change declared unlawful that should be made in the established religion before the determination of the approaching council was known. After many ineffectual remonstrances and arguments, six princes of the empire and thirteen imperial cities *protested* against this decision. Hence arose the denomination of *Protestants*; a term at first applicable only to the Lutherans, but now common to all who have separated from the church of Rome.

As the reformed doctrines in Germany had not yet been reduced to a system, the elector of Saxony ordered Luther and other divines to commit to writing the leading articles of their system, along with the principal points on which they differed from the church of Rome. In compliance with this order, Luther delivered to the elector at Torgau seventeen articles, hence called the Articles of Torgau.

In 1530, Charles convoked a diet of the empire at Augsburg, and directed the reformers to lay before it an account of their tenets in German and Latin. The work prepared by Luther and Melanchthon, and presented to the diet, was hence called the Confession of Augsburg, or *Confessio Augustana*. It was read aloud by the chancellor to the assembly. It contained twenty-eight chapters, of which twenty-one were illustrative of the religious opinions of the Protestants, and the remaining seven of the errors and superstitions of the papal faith. After much disputation the diet published a decree condemning most of the peculiar tenets held by the Protestants, and forbidding any person to protect or tolerate such as taught them. But the Protestants were now too powerful a body to be easily dismayed. They assembled at Smalcalde, where they concluded a treaty of mutual defence, both religious and political, against all aggressors, and formed the Protestant states of the empire into one regular combination. Thus, in the year 1530, the Reformation was virtually established in Germany; first, by the publication of the Confession of Augsburg; and, second, by the league of Smalcalde, which made that creed the bond of union of a powerful political confederacy.

It may here be mentioned that the followers of Zuinglius, or Sacramentarians, as they were sometimes called, presented their confession of faith on the part of four cities, Strasburg, Memmingen, Lindau and Constance; generally known by the Confession of Strasburg, or *Confessio Tetrapolitana*. The reformed cantons of Switzerland were not allowed to join the league of Smalcalde, inasmuch as they refused to sign the Confession of Augsburg; and thus the Swiss Evangelicals or Sacramentarians continued distinct from the Lutherans (as they still do), though they joined in a separate league with the city of Strasburg and the landgrave of Hesse, who adopted their views. The Helvetic Confession of Faith, founded on the articles of Berne already referred to, was finally published in 1532. The reformed doctrines had early spread to Geneva; and John Cauvin, or Calvin, of that city, after the death of Zuinglius, carried them farther than the Swiss Protestants had done. He abolished all festivals except the Sabbath, discarded all church ceremonies, used leavened bread for the sacrament, and taught the doctrines of predestination and election in all their rigour. [PRESBYTERY.] Calvinism thus became the third great branch of the Reformation, Luther and Zuinglius being respectively at the head of the other two. The systems of Zuinglius and Calvin, however, gradually merged together, and they may now be considered as one, having the same confession of faith.

Among other results (such as conferences, meetings of councils, particularly the celebrated council of Trent in 1549) the treaty of Smalcalde gave rise to a war between the emperor and the Protestants. But the peace of Augsburg, in 1555, terminated these calamities, which had so long agitated the empire. The following are the leading articles of the peace: namely, that the Protestants who followed the Confession of Augsburg should in future be free from the jurisdiction of the pope; that all the inhabitants of the German empire should be at perfect liberty to judge for themselves in all matters, religious and ecclesiastical; that all persons, whatever be their religious opinions, should enjoy equal civil rights and privileges, and that all those who should persecute any person under religious pretences should be declared and treated as public enemies of the empire. Thus was the Reformation finally established in many parts of Germany as it exists, without any very marked change either as to its extent or its principles, at the present day. This state of things was broken many years after by the Thirty Years' War (1619–48); but the treaty of Westphalia, which terminated this war, confirmed the articles of the peace of Augsburg, and extended its benefits to the Calvinists as well as to the Lutherans.

While these events were taking place in Germany and Switzerland, the doctrines of the Reformation found their way partially into France, and also into Spain and Italy. Prior to Luther's death (1546), these doctrines had made many converts in the Netherlands; and in the time of Philip II. the 'Seven United

Provinces,' which separated from the rest, proclaimed liberty of conscience, and adopted the tenets of Calvinism, to which they have ever since adhered.

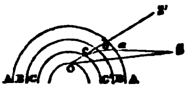
About the year 1556, the Lutheran creed was adopted as the state religion in Denmark and Norway. This creed was propagated in Sweden, soon after Luther's rupture with the church of Rome, by Olaus Petri, one of his disciples. Both Lutheranism and Calvinism early gained an extensive footing in Poland Hungary, and Transylvania. The Reformation in England did not extend to the hierarchical constitution of the church. In Scotland, episcopacy was rejected. [PRESBYTERY; COVENANTERS.] In Ireland, while the Protestant episcopal church is the established religion, more than three-fourths of the people retain their hereditary attachment to the papal creed. Altogether, not more than a fourth of the population of Europe are Protestant; of the remainder, about two-thirds still adhere to the Roman faith. The Protestant bodies predominate in the United States, and in almost all the British colonies. [CHRISTIANITY.] (Ranke's *History of Germany during the Reformation*; D'Aubigné, *History of the Great Reformation in Germany and Switzerland*; F. Paul, *History of the Council of Trent, &c.*; Burnet, *History of the Reformation*; Macaulay's *Essays, Von Ranke.*)

Reformatory. An institution for the reception and reformation of juvenile offenders under sentence for criminal offences. These appear to have originated in the efforts of philanthropic persons to establish places of refuge for such children after sentence. The statute 17 & 18 Vict. c. 86 first authorised the sending of children under sentence to these private foundations. But criminal courts are now, by 20 & 21 Vict. c. 55, enabled to sentence youthful criminals to detention in reformatories, which the magistrates of counties and districts are empowered to provide for this purpose, the parents being compellable, if able, to provide for their maintenance and education. Under later Acts, criminal or neglected children, not previously convicted of felony, may be sent for education and training to an *industrial* school (stat. 24 & 25 Vict. c. 113, &c.).

Refraction (Lat. refractus, *broken*). In Mechanics, the change of direction which takes place in the motion of a body when it passes obliquely out of one medium into another of different density. The term is chiefly applied to the deviation from their rectilinear course of the rays of light in passing through transparent substances.

Refraction, Astronomical. Refraction, in Astronomy, is the apparent angular elevation of the celestial bodies above their true places, caused by the refraction of the rays of light in their passage through the earth's atmosphere.

It is found by experiment that the refractive power of a gas, or aëriform substance, is proportional to its density. Now the earth's atmosphere is not a medium of uniform density, but of a density continually diminishing as the distance from the centre is increased. For the purpose of illustration, the atmosphere may be regarded as composed of a great but finite number of concentric spherical strata, each having a uniform density greater than that of the stratum by which it is enveloped, but less than that of the stratum which it envelopes. Hence, on entering each successive stratum the light must undergo a slight deviation from its rectilinear course, and the amount of all these deviations constitutes the phenomenon of astronomical refraction. Let A A, B B, C C, represent the boundaries of the successive strata, and suppose a ray of light proceeding from the star S to enter the highest stratum A A obliquely at a. If no deviation took place, the ray would continue to advance in the same straight line Sa; but in consequence of entering a denser medium it is refracted, according to the law of Descartes, into a direction ab, more nearly perpendicular to the surface of the spherical stratum. At b it again enters a medium of a greater density, and is refracted into the direction bc, still approaching the perpendicular to the surface. On arriving at c the phenomenon is repeated, and the ray is bent from the direction bc into the direction cO; so that in passing from S to O the ray of light, instead of describing the straight line SO, describes the polygon SabcO, and to a spectator at O the star will appear to be situated at S′ in the direction Oc. Hence the star appears to be elevated above its true place; and the angle S′OS, which is the difference between its true and apparent elevations, is the *astronomical refraction*. If we suppose the number of the strata to become infinitely great, then the angular deviation at each successive stratum will become infinitely small; and the path of the ray, instead of being a polygon, will be a continuous curve, which, according to the laws of refraction, will lie wholly in the same vertical plane.



Since the ratio of the sines of incidence and refraction is constant, it is evident that the total effect will be the greatest when the luminous rays enter the atmospheric strata with the greatest obliquity, i. e. when the object is seen in the horizon. At the zenith there is no refraction. In descending from the zenith to the horizon it continually increases, according to a certain law, which may be determined theoretically, if the refractive power of atmospheric air at a given density and temperature, the dilatation of air by heat, and also the law of the variation of the density and temperature in ascending into the higher regions of the atmosphere, are supposed to be known. At a medium density, and at the temperature of melting ice, Biot and Arago found by experiment that for any altitude exceeding 10° above the horizon the law of atmospheric refraction is represented by the formula

$$r = 60{\cdot}6'' \tan (Z - 3{\cdot}25 \times r),$$

in which r is the refraction corresponding to a given zenith distance Z. Bradley had given the formula

$$r = 57'' \tan (Z - 3{\cdot}25\ r).$$

From either of these it appears that the increase of refraction is nearly proportional to the tangent of the zenith distance, but at low altitudes the expression becomes much more complicated.

The following table, given by Mr. Ivory (*Phil. Trans.* for 1838, part 2), shows the amount of refraction at different zenith distances, the temperature being 50° Fahr. and the height of the barometer 30 inches. The correction (omitting some small terms) for the actual temperature and barometric pressure is obtained by multiplying the tabular refraction by $\dfrac{1}{1 + c\,(t - 50)} \cdot \dfrac{b}{30}$, where b is the observed height of the barometer reduced to the fixed temperature of 50° Fahr., t the temperature of the air on the same scale, and $c = {\cdot}002183$.

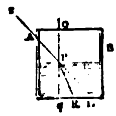
Zenith Distance	Refraction	Zenith Distance	Refraction
10°	10·30″	82°	394·68″
20	21·26	83	445·42
30	33·72	84	509·86
40	48·99	85	593·96
45	58·56	85½	646·21
50	69·52	86	707·43
55	83·25	86½	779·92
60	100·85	87	866·76
65	124·65	87½	971·93
70	159·16	88	1101·35
75	214·70	88½	1262·6
80	320·19	89	1466·8
81	353·79	89½	1729·5

The existence of astronomical refraction was known at an early period, though its amount and laws have been ascertained only in recent times. Ptolemy, in his book on *Optics*, remarks that in consequence of refraction a star is brought nearer the zenith, and that the effect is greater in the case of a low than a high star; but as no mention is made of the subject in the *Almagest*, we infer that it was not then regarded as an element of astronomical calculation. Similar notions appear in the *Optics* of Alhazen. Walther was the first who began to estimate the effects of refraction near the horizon; and Tycho Brahe constructed, from observations, the first table. He supposed the horizontal refraction to be 34′, which is very near the truth (its mean amount being 33′); but he supposed it to vanish at the altitude of 45°, though its mean amount at that altitude appears, by the preceding table, to be nearly 1 minute. Dominic Cassini gave an empirical formula for computing the refraction at any altitude; but the solution of the problem on true principles was first undertaken, and, in fact, fully accomplished, by Newton, though his results did not represent the observations, owing to the imperfect knowledge of that day respecting the physical constitution of the atmosphere. Our knowledge, indeed, as shown by Mr. Glaisher's recent balloon ascents, is at the present time by no means perfect.

Refraction of Light. The deviation of a ray of light from its original path in entering a medium of a different density. This change of direction, which takes place at the surface of separation of two media, is the ultimate fact from which many of the most interesting phenomena of light receive their explanation. The laws by which it is regulated, and the investigation of the consequences of those laws, form the branch of natural philosophy usually termed *dioptrics*.

The phenomenon may be observed as follows: Suppose a beam of light proceeding from a luminous point S (fig. 1) to be admitted through a small hole A in the side of a vessel A B: then, the vessel being empty, the light will fall on the bottom at a point L in the same straight line with S and A. Now let water be poured into the vessel, and suppose the beam of light to fall on the surface of the water at P; then it will be seen that the light no longer continues its course in the same straight line, but is bent, or *refracted* at P, and proceeds through the water in a straight line P R, more nearly perpendicular to the surface. A similar deviation takes place in all cases in which light passes from one transparent medium into another; but the magnitude of the angle RPL, or the amount of the refraction, varies according to the nature of the two media, and the degree of obliquity with which the incident ray falls on the surface of separation.

Fig. 1.



Through P draw QPq a normal to the surface; then SPQ is *the angle of incidence*, RPq *is the angle of refraction*, and the following laws are found to be observed in all cases:—

1. The refracted ray PR is in the same plane with SP and PQ; that is, with the incident ray and the perpendicular to the surface at the point of incidence.

2. The incident ray SP and the refracted ray PR are always on opposite sides of the perpendicular QPq.

3. Whatever be the inclination of the incident ray to the surface, the sine of the angle of incidence has to the sine of the angle of refraction a constant ratio.

The index of refraction of any transparent substance is the ratio of the sine of incidence to the sine of refraction, when light passes from a vacuum into the substance.

As there is no known substance of such a nature that light entering it from a vacuum is refracted so as to make the angle of refraction greater than the angle of incidence, the index of refraction is always greater than unity. Of all known substances, that which possesses the greatest refractive power is chromate of lead, for which the index of refraction is 3; hence in the equation $\sin i = n \sin r$, all the values of n which have yet been experimentally determined lie between 1 and 3.

Table of the Refractive Powers of Solid and Liquid Bodies.

	Index of Refraction		Index of Refraction
Realgar, artificial	2·549	Amber . .	1·547
Octahedrite . .	2·500	Plate glass, from 1·514 to . .	1·542
Diamond . .	2·439	Crown glass, from 1·525 . .	1·554
Nitrite of lead .	2·322	Oil of cloves .	1·535
Blende . . .	2·260	Balsam of capivi .	1·528
Phosphorus . .	2·224	Gum arabic .	1·502
Sulphur melted .	2·148	Oil of beech nut.	1·500
Zircon . . .	1·961	Castor oil . .	1·490
Glass: borate of lead . . .	1·866	Cajeput oil . .	1·483
Garnet . . .	1·815	Oil of turpentine	1·475
Ruby . . .	1·779	Oil of olives .	1·470
Glass: lead oxide 3 pts., flint 1 part . . .	2·028	Alum . . .	1·457
Sapphire . .	1·794	Fluor spar . .	1·434
Spinelle . .	1·764	Sulphuric acid .	1·434
Cinnamon stone .	1·759	Nitric acid . .	1·410
Sulphuret of carbon . . .	1·678	Muriatic acid .	1·410
Oil of cassia .	1·641	Alcohol . .	1·372
Balsam of Tolu .	1·628	Cryolite . .	1·349
Guiacum . .	1·619	Water . . .	1·336
Oil of anise seed .	1·601	Ice . . .	1·309
Quartz . . .	1·548	Liquids in minerals, 1·294 to .	1·131
Rock salt . .	1·557	Tabasheer . .	1·111
Sugar melted .	1·554	Ether expanded to thrice its volume	1·057
Canada balsam .	1·549		

Table of the Refractive Powers of Gases.

	Index of Refraction		Index of Refraction
Vapour of sulphuret of carbon .	1·001530	Carbonic acid .	1·000449
Phosgene . .	1·001159	Carburetted hydrogen . .	1·000443
Cyanogen . .	1·000834	Ammonia . .	1·000385
Chlorine . .	1·000772	Carbonic oxide .	1·000340
Olefiant gas .	1·000678	Nitrous gas . .	1·000303
Sulphurous acid .	1·000665	Azote . . .	1·000300
Sulphuretted hydrogen . .	1·000644	Atmospheric air .	1·000294
Nitrous oxide .	1·000503	Oxygen . .	1·000272
Hydrocyanic acid	1·000451	Hydrogen . .	1·000138
Muriatic acid .	1·000449	Vacuum . .	1·000000

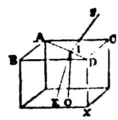
In the preceding remarks light has been regarded as a homogeneous substance, all the parts of which have the same index of refraction. This, however, is not the case; refraction never takes place without a separation of the different coloured rays, so that for every transparent body the index of refraction changes with the colour of the light. The numerical values of the indices, given in the above table, correspond to the yellow or green rays which occupy the middle of the dispersed pencil. For the different refrangibilities of the primary rays, see Chromatics; Dispersion; Spectrum.

Double Refraction.—The phenomena and laws of refraction, which have yet been considered, belong to those cases in which a single refraction takes place on the entrance of light into a different medium, or in which a pencil of light on entering a refracting medium continues to form a single pencil, and to afford a single image of the object from which it proceeds. There are, however, a multitude of substances which, either in their natural state or under accidental circumstances, exercise a peculiar influence on light, causing it, in its passage through them, to follow two distinct paths, forming with each other an angle of greater or less amount. Such substances are called *doubly refracting substances*, and the phenomenon itself is called *double refraction*.

The substances or media which produce only single refraction belong to one or other of the four following classes: 1. Gases and vapours. 2. Fluids. 3. Substances which have passed from the liquid to the solid state so rapidly as to prevent the molecules from taking a regular crystalline arrangement: for example, glass, glue, &c.; gums, resins, &c. 4. Crystals which belong to the regular system. All other substances, as the salts, precious stones, crystals not belonging to the above-named forms; all bodies belonging both to the animal and vegetable kingdoms, in which there exists any disposition to a regular arrangement of the molecules, as horn, mother of pearl, &c.; and in general all bodies unequally compressed, or which have not the same structure in all directions, separate the light which they refract into two distinct pencils, which pursue separate courses and are governed by totally different laws.

In order to give an idea of this remarkable phenomenon, let A B C D X (fig. 2) be a crystal of Iceland spar (carbonate of lime), having its faces made smooth either by cleavage or by grinding, and let it be laid on one of its faces on a sheet of white paper over a black spot O; then, on looking through the crystal, two spots will be seen, one at O, and the other at E. On turning the crystal round on its axis, but always keeping the same face on the paper, one of the images, O, will remain invariable, while the other, E, will appear to describe a circle about O. If instead of a round spot the object viewed be a straight line, then, on looking through the crystal, a double image of the line will be seen, one passing through O, and the other through E. On turning the crystal as before, it will be seen that the distance between the two lines varies, but that they always remain parallel to each other; and also that in the course of a complete revolution of the crystal about its axis there are two positions in which the images will coincide, and two other positions, midway between the former, in which they will attain a maximum distance. These phenomena show that a ray of light, S I, on entering the face of the crystal at I, is separated by refraction into two pencils, I O and I E; and it is found that on emerging from the crystals the two pencils make the same angle with the surface, and continue their course in a direction parallel to each other and to the incident ray S I.

Fig. 2.



If we cause a beam of solar light to fall on the crystal, and examine the paths of the two pencils, it will be found that I O follows the laws of ordinary refraction, the sine of incidence being to the sine of refraction in a constant ratio, and the pencil continuing in the same plane with the incident ray and the normal to the surface at the point of incidence; hence I O is called the *ordinary* pencil. But I E is found to follow an entirely different law, and is therefore called the *extraordinary* pencil.

If, for example, the incident ray S I is perpendicular to the face of the crystal, the ordinary refraction does not take place, the angle of incidence being zero; but in this case the angle of refraction of the extraordinary pencil, I E, is 6° 12′, and it is not in the same plane with the normal and the incident ray.

From a careful examination of the phenomena it is also found that although a ray of light falling on the face of the crystal is refracted generally into two pencils, there is one particular direction in which the incident ray undergoes only the ordinary refraction. This direction is parallel to A X, the shorter axis of the crystal, and is called the *axis of double refraction.* It is, therefore, to be observed that the axis of double refraction of a crystal is not a fixed line, but a determinate direction with reference to the faces of the crystal, every line parallel to A X forming an axis of double refraction. In some crystals the extraordinary ray is refracted *towards* the axis A X, in others it is refracted *from* it. In the first case the axis is called a *positive* axis of refraction; in the second it is called a *negative* axis.

In the crystal which we have now been considering (Iceland spar), there is only one direction in which the double refraction does not take place, but in many other crystals there are two directions which have this property. In examining the phenomena of double refraction in a great number of crystallised substances, Sir David Brewster found that all those crystals whose primitive and simplest form has only one axis of figure, or one pre-eminent line about which the figure is symmetrical, have only one axis of double refraction. The primitive forms which have only one symmetrical axis of figure are the following:—

1. The rhomb with an obtuse summit; as Iceland spar, tourmaline, quartz, &c.
2. The rhomb with an acute summit; of which form are corundum, sapphire, ruby, cinnabar, and arseniate of copper.
3. The regular hexahedral prism; as emerald, beryl, arseniate of lead, &c.
4. Octahedron with square base; as zircon, oxide of tin, prussiate of potash, &c.
5. Right prism with square base; as arseniate of potash, phosphate of magnesia, &c.

In all these forms, and in the primitive forms to which they belong, the line A X is the axis of figure and of double refraction; and it is the only direction in which there is no double refraction. (Brewster's *Optics*, p. 149.)

The property of possessing two axes of double refraction was discovered in 1815 by Sir David Brewster, who found that it belonged to all crystals, whether chemical bodies or mineral substances, which are included in the prismatic system of Mohs, or whose primitive forms are—

1. A right prism, base a rectangle.
2. A right prism, base a rhomb.
3. A right prism, base an oblique parallelogram.
4. Oblique prism, base a rectangle.
5. Oblique prism, base a rhomb.
6. Oblique prism, base an oblique parallelogram.
7. Octahedron, base a rectangle.
8. Octahedron, base a rhomb.

In all these forms there is no axis about which the crystal is symmetrical.

In all cases of crystals with two axes of double refraction, both the pencils are refracted according to the laws of extraordinary refraction. In a substance called analcime, Sir D. Brewster found that there were several planes along which if the incident ray passes it will not suffer double refraction, whatever be the angle of incidence. Each of these planes, therefore, may be considered as containing an infinite number of axes of double refraction, or lines in which there is no double refraction. No other substance has yet been found possessing the same property. (*Optics*, p. 155.)

Another very remarkable property is, that in crystals which have only one axis of double refraction the axis has always the same position, being, in fact, in all cases, the axis of symmetry; but in crystals which have two axes of double refraction, the axes change their position according to the colour of the incident light. Sir John Herschel, to whom this discovery is due, found that in crystals of Rochelle salt the inclination of the two axes for violet light is 56°, while for red light it is about 76°. In other crystals, as nitre, the inclination of the two axes is greater for the violet than for the red rays; but in all cases the line which joins the extremities of the axes for all the rays is a straight line.

The property of double refraction was discovered by Bartholin, in 1669, and was first explained by Huygens on the hypothesis of the propagation of light by means of an elastic medium. The phenomena have been studied with great assiduity in modern times, and, in fact, the investigation of their laws forms one of the principal parts of physical optics, and has mainly contributed towards the establishment of the now generally received theory of undulation. For the complete explanation of all the phenomena, the undulatory theory requires two postulates, or assumptions: 1. That the vibrations of the ether take place *transversely*, or in the direction perpendicular to the visual ray; and, 2. That the elasticity of the medium is unequally developed in the interior of the refracting crystal. The first of these assumptions is analogous to the effect of a blow given to a cord tightly stretched; the motion is communicated rapidly in the direction of its length, while the vibrations are at right angles to that direction. With respect to the second assumption, the facts which are known respecting the constitution of crystals render it exceedingly probable, à priori. All diaphanous bodies which refract light only in a single direction, and according to the Cartesian law, are found to have the same tenacity and the same elas-

ticity in all directions, and their linear dilatations by heat are also the same; but it has been established that with respect to all crystallised substances, which possess the property of double refraction, the elastic force with which they resist compression is greater in certain directions than in others, and also that the linear dilatation corresponding to the same increase of temperature varies with the direction in which it is measured. These facts prove that the matter of the crystal possesses an elasticity varying with the direction; and it seems natural to suppose that the ether within it must have the same property. On these two assumptions, namely, transverse vibrations, and unequally developed elasticity of the medium, Fresnel has constructed a mathematical theory of double refraction from which all the phenomena which have yet been observed are deduced as simple corollaries. (Sir J. Herschel's 'Treatise on Light,' *Ency. Metropol.*; Airy's *Mathematical Tracts*, 2nd ed.; Pouillet, *Élémens de Physique.*)

Refraction, Terrestrial. Atmospherical refraction [REFRACTION, ASTRONOMICAL] is the effect produced by the whole atmosphere on a body placed entirely beyond it; but as the density of the atmosphere varies with the height, it is evident that the apparent place of any object placed on a different level from that of the observer must be affected in a greater or less degree by refraction. Whether the rays of light come from a more elevated object and consequently pass from a rarer into a denser medium, or from an object depressed below the horizon of the observer and consequently pass from a denser into a rarer medium, they are equally bent downwards, and thus the apparent place of the object is raised. This refraction between terrestrial objects is called *terrestrial refraction*; and as the density of the air near the surface of the earth is liable to great irregularities from being irregularly heated, its effects give rise to many very remarkable phenomena. Among these are LOOMING or MIRAGE, the FATA MORGANA, and the occasional appearance above the horizon of distant objects which in the ordinary state of the atmosphere are invisible. Sometimes, in consequence of the rarefaction of the air in the neighbourhood of a surface of water, or of a building, or of the earth itself, a distant object appears to be depressed instead of being elevated; and occasionally it is at once both depressed and elevated, so as to appear double, in which case one of the images is generally seen in an inverted position, as if a reflexion had taken place. In very exact observations, as in geodetical surveys, it is found that the refraction is not always confined to the same vertical plane, but sometimes produces a deviation amounting to a few seconds laterally.

Refractive Power. In Optics, the degree to which a diaphanous body deflects a ray of light which passes through it. For the measure of this influence modern writers generally adopt the square of the index of refraction diminished by unity, or n^2-1, where n denotes the principal index of refraction. [REFRACTION.]

Some modern authors employ the phrase *absolute refractive power* to denote the ratio of the refractive power of a substance (as above defined) to its density; that is to say, the ratio $(n^2-1):D$, where D stands for the density of the body.

The French authors use the term *puissance réfractive* to denote the refractive power, or the number n^2-1, while they express the *absolute refractive power*, or the ratio $(n^2-1):D$, by the term *pouvoir réfringent*. It is convenient to have different names for the two things, which are totally different, at least in their numerical measures. Thus hydrogen gas has a smaller index of refraction, and consequently a smaller refractive power, than any other substance; but its *absolute refractive power*, or *pouvoir réfringent*, is greater than that of any other substance. (For a table of the values of the ratio $(n^2-1):D$ for a considerable number of different substances, see Brewster's 'Optics,' *Cabinet Cyclopædia.*)

Refractor. The name generally given to the refracting telescope. [TELESCOPE.]

Refractory Minerals. Such minerals as can bear exposure to great heat without change or injury. The most important of these are Mica, Graphite or Plumbago, Steatite or Soapstone, Potstone, Pyrallolite, Fire-clay, some kinds of sandstone, &c.

Refrain (Fr. refrein). The burden of a song, &c. [BOURDON.]

Refrangibility (Lat. re, and frango, *I break*). In Optics, the disposition of the rays of light to be refracted or bent in passing obliquely from one transparent medium into another. The term is chiefly used to denote the degree of that disposition possessed by the differently coloured rays. [REFRACTION; SPECTRUM.]

Refresher. In Law, an additional fee paid to counsel when a cause is not heard in the term for which it was originally set down.

Refreshment Houses. In Law, houses kept open at night for public refreshment or entertainment, but not licensed for the sale of beer, cider, wine or spirits. They are placed under special regulations by stat. 23 Vict. c. 27 and subsequent Acts.

Refrigerator (Lat. refrigero, *I make cool*). A term sometimes applied to a system of pipes contained in tanks of cold water, and used for the cooling of large quantities of liquids, which are made to circulate through the pipes. More usually, however, the word is used as synonymous with CONDENSER.

Refuge, Cities of. Six cities mentioned in the Pentateuch as appointed for the reception of those who had caused the accidental death of anyone. It is stated that if a deliberate murderer should flee to one of these cities, the elders of the city are to deliver him 'into the hands of the avenger of blood.' (Deut. xix.; Josh. xx.)

Refugee. A name which has been given indiscriminately to persons who flee from religious or political persecution in their own country, and take refuge in another. It was originally applied to the French Protestants (réfugiés) who found an asylum in this country and in others after the revocation of the Edict of Nantes by Louis XIV.

Regalia (Lat. *royal things*). In English Heraldry, the royal insignia, crowns, sceptres, globes, crosses, &c. used at the coronation: also the crown jewels.

REGALIA. In Politics, the privileges, prerogative, and right of property, belonging in virtue of office to the sovereign of a state. The latter class of objects are most commonly termed *regalia minora*, as, in some countries, waifs, strays, and newly-formed land, &c.; in England, forfeitures, &c.; while the former are known by the epithet *majora*.

Regalia of the Church. The privileges which have been conceded to it by kings; sometimes the patrimony of a church.

Regardant (Fr.). In Heraldry, literally *looking behind*; applied to any animal whose face is turned towards the tail in an attitude of vigilance.

REGARDANT. In Law, a *villein regardant* was probably so called because annexed to a manor regarding or relating to it.

Regarder. The obsolete title of an officer whose duty it was to overlook a forest. [RANGER.]

Regatta (Ital.). A word used originally by the Venetians to signify a grand fête, in which the gondoliers contested for superiority in rowing their gondolas; but the term has been adopted into all the languages of modern Europe, in which it signifies a brilliant species of boat race.

Regel or **Rigel.** A star of the first magnitude, in the left heel of the constellation Orion.

Regenerating Furnace. A furnace lately introduced, which acts by causing the products of combustion, on their way to the stack or chimney, to pass over an extended surface of brick, metal, or other suitable material, capable of retaining heat, which afterwards serves to heat the atmospheric air, or other materials of combustion, in such manner that the cold air is first brought into contact with the more intensely heated portions, until it finally passes the surfaces nearest the place of combustion, which are consequently heated to the highest point. Usually four chambers filled with firebrick are employed, one pair receiving the waste heat while the other pair, previously heated, are giving up their acquired heat to the gaseous fuel and to the air required for burning it. The direction of the currents is changed by a simple system of reversing valves. The regenerative furnaces are largely applied in the operations of the glass blower and plate-glass maker, in the pottery and porcelain factories, also in puddling and welding iron, and cast-steel melting. Attempts have been made to introduce them in gas-works, and they appear to be very successful in all cases where intense heat combined with a regularity of draught is attainable. The best description of this kind of furnace is to be found in Mr. Siemens' patent; and the *Practical Mechanic's Journal* for October 1, 1864, contains a good account of the application of the principle to the burning of bricks.

Regeneration (Lat. regeneratio). In Theology, this term is used to denote the new birth of man unto righteousness, following on the abolition of the original corruption of his nature. Similar language was used respecting the admission of proselytes to the privilege of Judaism: so, also, in other religions. The Sanscrit name for a Brahman is said to signify *twice born*; and Tertullian says that the heathens used baptism in their mysteries, *in regenerationem*.

Regent (Lat. rego, *I govern*). The person who exercises the powers of a sovereign during the absence, incapacity, or minority of the latter. In most hereditary governments the maxim is, that this office belongs to the nearest relative of the sovereign capable of undertaking it; but this rule is subject to many limitations. The kings of France exercised at various periods the power of fixing, by ordinance or will, the regency, in case of their decease leaving issue under age; and also the period of their son's majority. Nevertheless, these wills have been at various times disregarded in favour of what was esteemed the principle of the monarchy. Thus, the testament of Louis XIII., by which he declared his wife future regent, but limited her power in the essential prerogative of the choice of a council, was set aside as to this limitation, and she was appointed regent with full prerogatives. The testament of Louis XIV., as to a regency during the minority of Louis XV., was set aside by the parliament of Paris immediately after his death. In England, the right to appoint the regent is now fully recognised to belong to parliament; although, in 1788, on the occasion of the first illness of George III., much discussion took place as to the absolute right which some supposed to inhere in the heir apparent.

Regent Masters or **Regents.** In the English Universities, a term borrowed from the ancient usages of the university of Paris. In that institution graduates in the faculties, within a certain period after their degree, had the privilege, which they were bound to exercise, of giving public lectures (docendi, legendi, regendi scholas). The same custom was adopted at Oxford and Cambridge; although the regent masters were at an early period succeeded in the performance of this office by the established professors. [MASTER OF ARTS.]

Regicide (Lat. rex, *king*, and cædo, *I kill*). The offence of slaying a king or other sovereign. The early Greek republics, unaccustomed to the legitimate rule of monarchs, saw, in the occasional subjugation which they underwent from successful partisans, a mere usurpation,

or tyranny; and tyrannicide was with them only the slaying of a public enemy. The ancient Greeks made a wide distinction between hereditary sovereigns, whether constitutional or despotic, and those who had risen to absolute power by subverting an existing free constitution. With them the former was an object of respect, and was regarded as having a right to the obedience of his subjects; the latter was in their eyes simply as a wild beast who had burst into the fold of civil society, and whom every citizen was bound by whatever means to destroy. (Arnold, *History of Rome*, i. 476.) The hatred which grew up in the minds of the Roman people to the royal name and authority made them regard the acts assigned by tradition to the elder and younger Brutus, even to the latest days of the republic, and long after the establishment of the empire, as virtuous and honourable. Hence arose a perverted morality on this peculiar subject, which continues to prevail, more or less, even to the present day, as false in logic as contrary to the plain rules of conscience; for it is obvious that, to each individual, any wealthy or powerful oppressor, who commits injuries against him and his friends for which the law can give no redress, is just as fair a subject for illegal vengeance as a king to any member of the community. Yet no one ever sought seriously to set up the right of assassination in such cases; as Buchanan, Languet, Mariana, and others have done in that of kings. English history has three notorious instances of kings (Edward II., Richard II., and Edward V.) murdered by powerful and rebellious subjects. In France, Henry III. and IV. both fell by the hands of Roman Catholic zealots. But the savage execution of Ravaillac did not deter Damien, in the reign of Louis XV., from attempting the same offence from the same motives. The murder of the duc de Berri, and the repeated attempts on the life of Louis Philippe, from political enthusiasm, together with well-known recent instances, show but too plainly that the morbid passions which actuated these celebrated assassins have but taken in modern times another direction. The murder of Gustavus, king of Sweden, by Ankarström, is, perhaps, the most deliberate instance of this crime on record; for the criminal, though rancorous and determined, was no zealot. It must be added, that the application of the term *regicide* to the members of the commission which sat in judgment on Charles I., and to the majority of the convention which condemned Louis XVI., is a violation of that moral sense which judges unerringly of actions; whatever the character of their conduct might be, it was altogether different from assassination; and to confound Vane or Carnot with Ravaillac and Fieschi, under a similar designation, can serve no ends but those of temporary party malice. By the law of some continental countries, regicide is punished as PARRICIDE. (Hallam, *Literary History*, part ii. ch. iv. §§ 29-40, and part iii. ch. iv. § 2.)

Regifugium (Lat. *the king's flight*). A festival celebrated by the Romans to commemorate the expulsion of Tarquin the Proud. It is, however, doubtful whether the institution of this feast has anything to do with the flight of Tarquin; and the symbolical flight of the *rex sacrorum* from the Comitium after performing his sacrifice has been alleged as accounting for the origin of the tradition.

Regiment (Lat. rego, *I rule*: the Latin regimentum, like regimen, denoted *rule* or *authority*, and the word was used in this sense by Knox when he denounced the 'monstrous regiment of women'). A body of troops consisting (if infantry) of one or more battalions or (if cavalry) of several squadrons, under the command of a colonel. The royal regiment of artillery consists of thirty-one brigades, six of which are *horse brigades*. The British army consists at present (1866) of three regiments of life and horse guards; twenty-eight regiments of cavalry, of which ten are dragoons, thirteen hussars, and five lancers; three regiments of foot guards, divided into the Grenadier guards, the Scots fusiliers, and the Coldstream guards; and one hundred and nine regiments of infantry exclusive of the rifle brigade, besides ten colonial regiments and corps, the native troops in India, artillery, engineers, military train, marines, &c. Many of the regiments in the British army are distinguished by the name of the counties or districts where the men were originally enlisted. Thus the 3rd regiment is called the East Kent regiment; the 6th the Royal Warwickshire, &c. &c. No rule is established with regard to the number of men of which a regiment should consist: both in England and on the Continent this point is settled either by the exigencies of service in time of war, or the principles of economy in time of peace. [ARMY; ARTILLERY; CAVALRY; INFANTRY.]

Regin. In Mythology. [SIGURDR.]

Register, Lord, or Lord Clerk Register. A Scottish officer of state, who has the custody of the archives; hence also termed *custos rotulorum*. He was formerly the principal clerk of the kingdom, from whom other clerks derived their authority. The office since 1777 has been held for life. It is now merely honorary, the salary having been abolished in 1861, and the duties being performed by the registrar-general and depute clerk register.

Registrar (Low Lat. registrarius) The keeper of a registry. Many officers with this title exercise different functions in the Courts of Bankruptcy, Chancery, &c.

Registration of Title to Land. [TITLE.]

Registry of Births, Marriages, and Deaths. Down to the year 1836, in consequence of the defects of the system of registration, no complete or accurate information could be obtained as to the number of births, marriages, and deaths throughout England; but at that period the need of a better system was admitted, and the change was finally ac-

complished by the Act 6 & 7 Wm. IV. c. 86. [MORTALITY, BILLS OF.]

This Act, passed in pursuance of the recommendation of a committee of the House of Commons on parochial registers (1833), embodies a plan for the effectual registration of births, deaths, and marriages in England and Wales. To give uniformity to the system, it is conducted under the superintendence of an officer resident in London; and there also a central place of deposit is provided for certified copies of all parochial registers, with ready means of finding any entry in them. It is provided that in every case of *birth* the following circumstances shall be recorded: viz. the time and place of birth; the name (if any) and sex of child; name and surname of father; name and maiden surname of mother; rank or profession of father; the signature, description, and residence of the informant; and also the baptismal name of child, if added after registration of birth. In every case of *death* the register is to record the time and place of death; the name and surname, sex, age, and rank or profession of the deceased; *the cause of death*; and the signature, description, and residence of the informant. In all cases the entries must be signed by the informant, and also by the registrar, who discharges this duty without any immediate expense to the parties requiring registration, his remuneration being derived from moderate fees paid out of the poor's rates. The insertion of the cause of death, along with the period of death, and the residence, sex, age, and occupation of the deceased, will, in time, afford data of the utmost importance to medical science, and to the improvement of vital statistics.

The central office in London for the deposit of certified copies of registers, and the general supervision and conduct of the business of registration, is called the General Register Office. It is presided over by a registrar-general appointed under the great seal, having under him an assistant registrar, chief clerk, and a numerous body of subordinate clerks. From this office communications emanate to all superintending registrars, registrars of births and deaths, and registrars of marriages, who all act within their respective districts under the directions of the registrar-general, in whom is vested the power of dismissal.

There are upwards of 600 superintendent registrars, who may each appoint a deputy, with the approval of the registrar-general. Each superintendent registrar serves within the district to which he is appointed, which comprises one or more registrar's districts.

There are upwards of 2,000 registrars of births and deaths, who may each appoint a deputy, with the approval of the guardians, or of the poor law commissioners. Each registrar is appointed to some one of the registrars' districts, into which the whole of England and Wales has been divided; and he must reside in that district and register *all* births and deaths that occur in it.

Marriages are registered, 1st, By clergymen of the established church, of whom about 12,000 have been furnished with books for this purpose. 2ndly, By registrars of marriages, of whom there were, on the 1st of January, 1850, about 1,000: these last are appointed by the superintendent registrars, and register marriages solemnised in their presence in registered places of worship, or in the superintendent registrar's office. 3rdly, By the registering officers of Quakers. And 4thly, By the secretaries of synagogues.

The clergymen and the various officers, amounting in all to about 15,000, to whom the business of registration is committed, are bound to make quarterly deliveries of *certified copies* of all entries in their respective registers during the previous quarter, to the superintendent registrars of the district to which they respectively belong; and these certified copies are transmitted by the superintendent registrars to the registrar-general. The certified copies are made on separate leaves of paper of a uniform size and peculiar texture, having a distinguishing water-mark. On being received at the general register office in London (whither they are sent by post), they are carefully examined; and any defects, which may be noted, are made the subject of communication with the person from whom the defective copy came, and who is required either to furnish another copy or a satisfactory explanation. They are then arranged, paged, and inserted in books for reference.

Alphabetical indexes of births, deaths, and marriages are prepared and kept in the general register office; and any person, on payment of 1*s*., may search these indexes for any entry, and on finding it, may, if he wish, obtain, for 2*s*. 6*d*., a stamped copy of such entry, which will be 'received as evidence of the birth, death, or marriage to which the same relates, without any further or other proof of such entry.' There are separate alphabetical indexes for the births, the deaths, and the marriages in each quarter. The registrar-general is bound to furnish, once a year, to one of the principal secretaries of state a *general abstract account* of the births, deaths, and marriages registered during the foregoing year, to be laid before parliament. The first of these was prepared in 1838. They have since been continued with various improvements; and in a statistical point of view, the sound, accurate, and judicious information which they embody, cannot be too highly appreciated. (*Stat. of the Brit. Empire*, vol. i. pp. 410–430.)

The Act 6 & 7 Wm. IV. c. 86 does not extend to Scotland or Ireland, but similar provisions have been recently enacted for both these portions of the empire (7 & 8 Vict. c. 81, 26 & 27 Vict. c. 11, c. 90, for Ireland; 17 & 18 Vict. c. 80 &c. for Scotland).

Registry of Deeds. In Law. In England conveyances (including wills) of land situate in the three ridings of Yorkshire, or in Middlesex, must be registered according to the provisions

of certain special Acts of Parliament. This does not extend to copyhold estates, or to leases not exceeding twenty-one years in possession. The intention of the registry was to give notice, to purchasers, of incumbrances existing on estates; but its value, in this respect, is materially lessened by the prevalence of the equitable doctrine of *notice*; namely, that where a party is, either actually or constructively, aware of incumbrances not registered, he is bound by such knowledge. In Ireland and Scotland, and in most of the colonies, if not in all, there is a general system of registry, and many unsuccessful attempts have been made to induce parliament to establish a similar system for the whole of England.

Registry of Ships. [SHIPS, REGISTRY OF.]

Registry of Title. [TITLE.]

Regium Donum (Lat. *royal gift*). An annual grant of public money for the maintenance of the Presbyterian clergy in Ireland. It was instituted by William III. in 1690, and remodelled in 1790. The stipends are paid to ministers both of the Synod of Ulster and the Seceding Synod.

Regius Professor. The name given to those professors in the English universities whose chairs were founded by Henry VIII. In the Scotch universities, in which the patronage of by far the greater number of chairs is vested in the civil bodies, those professors are called regius professors who have been appointed by the crown.

Reglet (Fr.). In Architecture. [FILLET.]

REGLET. In Printing, a sort of furniture of an equal thickness throughout its length, and of quadrat height. The length is three feet, and the thickness that of the various sizes of types.

Regma (Gr. ῥῆγμα, *a fracture*). One of the terms applied to a tricoccous fruit, like that of the Castor-oil plant and the *Euphorbias*.

Regrating. [FORESTALLING.]

Regression (Lat. regressio, *a going backwards*). In Astronomy, the *regression of the moon's nodes* is the motion of the line of intersection of the orbit of the moon with the ecliptic, which is retrograde, or contrary to the order of the signs. This motion of the nodes of the lunar orbit takes place with considerable rapidity, the whole revolution being accomplished in about eighteen and a half years. The nodes of the planetary orbits also regress on the ecliptic; but, in the case of the planets, the regression is extremely slow, that of the nodes of Mercury, which is the most rapid, amounting only to about 42 seconds of a degree in a solar year. [NODE; PLANET.]

Regression, Edge of. [CUSPIDAL EDGE; EDGE OF REGRESSION.]

Regular (Lat. regularis, *according to rule*). In Botany, a term applied to flowers which have all the parts of each series of a similar form and size. Thus the Buttercup is regular, while the allied Larkspur is irregular.

Regular Clergy. [REGULARS.]

Regular Polygon. In Geometry, a plane rectilineal figure with equal angles and sides. [POLYGON.] It is always possible to describe a circle whose circumference shall pass through all its corners or touch all its sides. [INSCRIBED AND CIRCUMSCRIBED FIGURES.] If a be the side of a regular polygon of n sides, then the radii of its *circumscribed* and *inscribed* circles are, respectively,

$$\frac{a}{2\sin\frac{\pi}{n}} \text{ and } \frac{a}{2\tan\frac{\pi}{n}},$$

and its area is $\frac{a^2}{4}\frac{n}{\tan\frac{\pi}{n}}$.

Regular Polyhedron. In Geometry, a polyhedron whose faces are all equal and similar regular polygons. There are only five such solids, and these, from their discoverer Plato, are sometimes called also the PLATONIC BODIES. [POLYHEDRON.] If n be the number of sides, each equal to a, which form each face, and m the number of plane angles which meet at each corner of the regular polyhedron, then the inclination θ of any two adjacent faces is given by the formula—

$$\sin\frac{\theta}{2} = \frac{\cos\frac{\pi}{m}}{\sin\frac{\pi}{n}},$$

the radius of the inscribed sphere is equal to

$$\frac{a}{2}\frac{\tan\frac{\theta}{2}}{\tan\frac{\pi}{n}},$$

and the radius of the circumscribed sphere is equal to

$$\frac{a}{2}\tan\frac{\theta}{2}\tan\frac{\pi}{m}.$$

The area of the surface is, of course, easily found from that of one face [REGULAR POLYGON], and the volume of the solid from that of the pyramid having one of the faces for its base, and the radius of the inscribed sphere for its altitude.

Besides the five regular polyhedrons of Plato, there are the *semi-regular* ones of Archimedes, for an account of which see POLYHEDRON.

Regulars. In the Roman Catholic Church, those who profess and follow a certain rule of life, and observe the three vows of poverty, chastity, and obedience. Hence monks in holy orders constituted the body of the regular clergy, as distinguished from the seculars, or clergy who were not under vows.

Regulator. In Machinery, a general name for any contrivance of which the object is to produce the uniform movement of machines. The regulators most commonly applied are the FLY and the GOVERNOR, for which see the respective terms.

The regulator of a watch is the spiral spring attached to the balance. This ingenious contrivance, the invention of Hooke, has contributed as much to the improvement of watches as the pendulum to the improvement of clocks.

In a paper published in the *Memoirs of the Royal Astronomical Society*, vol. xi., the present Astronomer Royal has investigated the mathematical problem of the motion of the regulator applied to the clock-work by which motion is given to large equatorial telescopes. For this purpose absolute uniformity of motion is of very great importance. The construction usually adopted, in this country at least, depends on the same principle as that of the governor of the steam engine. Two balls suspended from the upper part of a vertical axis by rods of a certain length, are made to expand by the rotatory velocity of the axis; and when the expansion reaches a certain limit, a lever is pressed against some revolving part, a friction being thus produced which immediately checks the velocity. Now the uniformity of the rotatory motion of the spindle depends upon the assumption, that if upon the whole the retarding forces are equal to the accelerating forces, the balls will move in a circle, and in no other curve. But this assumption is incorrect; for the balls may move in a curve differing insensibly from a circle; and, in some instances, Mr. Airy observed the balls to revolve in an ellipse of considerable eccentricity. When this takes place, the rotatory motion of the spindle becomes exceedingly variable. This injurious effect may be partly counteracted by constructing the apparatus so that the revolutions shall be either very slow or very quick: the former method has the effect of giving greater smoothness of motion, but the second insures more completely that the object observed shall remain steady in the field of the telescope.

Regulus (Lat.). In Chemistry. The old chemists designated by this term several of the brittle or inferior metals when freed from impurities and obtained in their metallic state. Thus they speak of *regulus of antimony*, *of bismuth*, &c. The term is now often used by metallurgists to denote the metallic button which is found at the bottom of an assay crucible.

There is still, however, considerable confusion in the use of this term; thus German assayers use it in the sense just given, whereas in England it usually signifies a mass of sulphides, and especially of copper, such as is got in the concentration of poor copper ores by fusion.

Regur. The name given to the cotton soil of India, which extends over at least one third part of Southern India, and ranges northwards to some distance. It chiefly characterises the high plateaux of the Deccan, covering the nearly level plains of that district. Its colour is bluish-black, greenish, or dark grey. It forms a paste with water, and has a clayey odour when breathd on. It absorbs moisture rapidly, and dries into a powder in hot weather. Its thickness varies from three to twenty feet, and it may be cultivated year after year without manure, almost without husbandry, and with very rare fallows. It consists of about 50 per cent. silica, 20 per cent. alumina, and 25 per cent. of the carbonates of lime and magnesia. The quantity of organic matter is small.

Rehabilitation (a word coined from Lat. re, and habilis, *active*, in the sense of restoration to vigour). In Foreign Criminal Law, the reinstatement of a criminal in his personal rights, which he has lost by a judicial sentence. Thus, in Scotland, a pardon from the king is said to rehabilitate a witness labouring under *infamia juris*. In France, persons condemned to imprisonment or compulsory labour may demand their rehabilitation five years after the expiration of their penalty.

Rehearsal. The recital in private of any dramatic work, previously to public exhibition.

Reichsrath (Ger. *council of the empire*). Under the old constitutions of the German empire, the reichshofrath was a council of state, charged with important judicial functions. [Aulic Council.] In the Austrian empire, the reichsrath answered to the senate in France, and aided the sovereign in the administration of the empire. But by imperial patent of March 1860, the emperor reconstituted this body by adding to the original or *narrow* reichsrath (consisting of eighty members) other representative members to be elected by the provincial assemblies: to take into consideration, (1) the annual budget; (2) the more important bills for enactment into general laws; (3) the proposals of the provincial constitutions. The species of constitution thus established has been very recently subjected to innovations, intended to take from the power of the reichsrath and add to that of the several legislatures of the provinces comprising the empire.

Reichstadt (Ger. *city of the empire*). The designation given to the several free cities which under the old German constitution held immediately of the empire. Of these Hamburg, Frankfort, Bremen, and Lubeck now alone retain their independence. [Hansa.]

Reichstag. [Diet.]

Reindeer (Ger. rennthier). *Cervus tarandus*, Linn. A large species of *Cervus* with branched, recurved, sub-compressed antlers, the summits of which are palmated. These antlers are remarkable for the size of the branch which comes off near the base, and is directed forwards, called the *brow-antler*, and which is said to be used by the animal to clear away the snow from the hidden lichens which constitute its food during the long and severe winter of Greenland, its native clime. As the female also possesses antlers of similar form, but smaller upon the whole than those of the male, their function as instruments to obtain food is rendered more probable, since in the deer which do not exist in arctic climes the females are destitute of antlers. These appendages of the

reindeer are annually shed and renewed in both sexes.

The length of a full-grown male is about nine feet, that of the head is fifteen inches. They are well clothed with hair, which becomes thicker, longer, and of a whiter colour in the winter season; at which time the male has a white beard like the goat. The rutting season is at the beginning of winter, and the hind brings forth one, rarely two, calves in May or June.

The reindeer is swift of foot, sharp-sighted, and has an acute smell and hearing. It is more cautious and timid in herds than when solitary. It can swim well, and often crosses lakes and rivers.

The flesh of the reindeer, which is held in great esteem by the Greenlanders, is usually eaten raw, or dried with the smoke of the *lichen nivalis*. The blood is boiled with berries mixed with the fat, which is also preserved separately and used as lard. The half-digested contents of the paunch of the reindeer form the Greenlander's prime luxury; nor is the tail rejected. The hide of the reindeer supplies the Greenlander with a beautiful material for his tent, his clothing, and his bedding. The bones and antlers are worked into implements for domestic use, for fishing and hunting. The tendons are split into threads. The Greenlanders likewise use the spare hides of the reindeer as an article of barter.

Reinecke the Fox. The name of a celebrated popular German epic poem, which, during the latter part of the middle ages and the early centuries of modern times, enjoyed an almost European reputation, having first become known through the medium of a Low German version in the fifteenth century. It contains a humorous and satirical account of the adventures of Reinecke (the fox) at the court of King Nodel (the lion); exhibits the cunning of the former, and the means which he adopted to rebut the charges preferred against him, and the hypocrisy and lies by which he contrived to gain the favour of his sovereign, who loaded him with honours. The king, the officers of his court, and all his subjects are represented, as in *Æsop's Fables*, under the names of the animals best suited to their respective characters; and the poem is an admirable satire on the intrigues practised at a weak court. The most successful versions of this poem are those of Goethe, in hexameters; of Soltau, in the measure of the original; and the more recent attempt of Ortlepp.

This poem appears, in some form or other, to have been known throughout Europe. For full information respecting it, the reader may consult Meon, *Roman du Renard*, Paris 1826; and the *Reinhart Fuchs*, by Jacob Grimm, Berlin 1834.

Reinforce. In Artillery. This word was used originally to signify an additional thickness of metal, given to *reinforce* or strengthen the gun about the breech. Though still employed in the same sense in America, it has now in England almost lost this meaning, and is generally understood to signify the part of the gun thus *reinforced*.

A smooth-bored cast-iron or bronze gun is divided for purposes of nomenclature into parts. That portion of the gun between the base ring and the ring nearest to the trunnions is divided into two parts, called respectively *first* and *second reinforce*. [Gun.] Rings round the gun where these parts end are called *reinforce rings*.

Reis, Rais, or **Ras** (Arab. *head*, *prince* or *chief*). A title popularly used for various persons in authority in different parts of the wide regions over which the Arabic language more or less prevails: e.g. the captain of a ship. In Bengal, managers or occupants of religious endowments are sometimes so termed.

Reis Effendi. The name given to one of the chief Turkish officers of state. He is chancellor of the empire and minister of foreign affairs, in which capacity he negotiates with the ambassadors and interpreters of foreign nations.

Reiters. The German cavalry of the fourteenth and fifteenth centuries were so called; especially in France during the religious wars, in which they served on the Protestant side. At that period they were light-armed, and carried a long sword and carbine.

Rejoinder. In Law, the fourth stage in the pleadings in an action, being the defendant's answer to the plaintiff's replication. [Pleading.]

Relapsed (Lat. relapsus, part. of relabor, *I fall back*). A term applied, in Ecclesiastical Law, to a heretic who falls back into an error which he has abjured.

Relation, Inharmonic or False. In Music, a term denoting that a sound is introduced which has a dissonant or false relation with some sound in the preceding chord.

Relative Magnitude. [Ratio.]

Relative Motion. [Motion.]

Relative Pronoun. In Grammar, a part of speech which, while it may represent any noun or prepositive pronoun, possesses also a connective force which makes the clause introduced by it practically an adjective. Thus the words, 'A man who speaks much is not likely to be wise,' may be resolved into the expression 'A man of many words is not likely to be wise.'

Relative Terms. In Logic, words which imply a relation, as father and son, master and servant.

Relator (Lat.). When a suit in chancery is instituted in a public matter not directly touching the rights of the crown, e.g. for the regulation of a charity, the course is for the attorney-general to file an *information* on the *relative* of some person. This person is called the *relator*, and is responsible for the costs of the suit, in which he is in fact usually the real plaintiff. A similar name is given to the person at whose instance an information in the nature of a *quo warranto* is filed.

Relbun. The roots of *Calceolaria arachnoidea*, which are used in Chili for dyeing woollen cloths crimson.

Release (Lat. relaxare, *to loosen*). In Law, this word signifies, properly speaking, a discharge of a right; e.g. 1. A release of land is a discharge or conveyance of a man's right in lands and tenements to another that has some former estate in possession, on which principle the mode of conveyance by lease and release in use formerly (before land could be legally conveyed by a simple deed of grant) was founded; i. e. releasing all the right of the releasor to a party already in possession under a lease for a year. 2. A release of a right of action or suit, or of some right, claim, demand, &c. It is usual to express these releases in very general terms, but the Court of Chancery will nevertheless interfere to prevent their being used as a defence against any claims or demands but those of which the parties were aware, and from which in fact they designed to be released.

Relics (Lat. reliquæ). In the Roman and the Eastern communions, the remains of saints, or of their garments, &c., which are enjoined to be held in veneration and are considered in many instances to be endued with miraculous powers. They are preserved in the churches, to which they are often the means of attracting pilgrims.

Relief (Ital. rilievo). In Architecture, the projection of a figure or ornament from the ground or plane on which it is sculptured.

Relief. In Feudal Law, this term is derived from the Latin relevare, *to take up*; because the tenant, by payment of the relief, was said to take up the fief which had fallen to the lord by the death, &c. of his predecessor. 'The heir,' says Blackstone, 'when admitted to the feud which his ancestor possessed, used generally to pay a fine or acknowledgement to the lord in horses, arms, money, or the like, for such renewal of the feud; which was called a relief, because it raised up and re-established the inheritance, or, in the words of the feudal writers, "incertam et caducam hæreditatem relevabat."' Reliefs, together with the other incidents of feudal tenure, were abolished in England by stat. 12 Ch. II. [Feudal System.]

Relief. In Fortification, the relief of any point in a work is its vertical distance from a horizontal plane coincident with the base of its scarp. The relief of a work implies the relief of the crest of the parapet, i. e. its height above the base of its scarp.

Relief. In Military language, the party detached from a guard to relieve the old sentries at the expiration of their term on duty.

Relief. In Sculpture, when the whole of the figure stands out, the work is denominated *alto-rilievo*; when only half out, *mezzo* or *demi-rilievo*; and when its projection is very small, it is called *basso-rilievo*.

Relief Synod. A body of Presbyterian dissenters in Scotland, whose ground of separation from the established church was the violent exercise of lay-patronage which obtained in the latter. Though patronage, or the appointment of clergymen to church benefices by presentations, had been established by Act of Parliament in 1712, yet a minority of the clergy were opposed to the intrusion of a minister into a parochial charge contrary to the sentiments of the people. The majority of the church, however, rigorously enforced the provisions of the Act of 1712. With this state of things the people generally, but particularly in rural districts, were dissatisfied; and hence the origin of the Secession church, and the Relief. [Burghers.]

The origin of the Relief may be dated in 1752. Six of the ministers of the Presbytery of Dunfermline having refused to assist at the admission of Mr. Richardson to the parish of Inverkeithing (the people being unwilling to receive him as their pastor), were summoned before this court for contumacy; and, as an example to the church, one of the six recusants was peremptorily deposed from the office of the ministry, while the remaining five were suspended. Mr. Gillespie, minister of Carnock, the person deposed, still claimed his pastoral relation to his flock; and though deprived of the use of the parish church, preached in the fields, attended not merely by his former hearers, but by many others attracted by the circumstances of the case. Gillespie for a few years stood alone; but in consequence of the violent settlement of a clergyman in the town of Jedburgh, the great body of the people of that place, forsaking the established church, gave a call (1759) to Thomas Boston, minister of a neighbouring parish, who accepted the invitation, and withdrew from the church of Scotland. The people of the parish of Kilconquhar, in Fifeshire, followed the example set them in Jedburgh, and chose Mr. Collier to be their minister. On the 22nd of November, 1759, Gillespie and Boston, with a lay elder from each of their congregations, met in a presbyterian capacity at Colinsburgh, in the last-mentioned parish, to induct Collier to his charge. On the evening of the same day these three ministers met, and agreed to form themselves into an ecclesiastical body, to be called the 'Presbytery of Relief, for the relief of Christians oppressed in their Christian privileges.' This sect gradually formed itself into a synod, which, in 1851, embraced eleven presbyteries, including 116 congregations; being, in point of numbers and influence, the third ecclesiastical body in Scotland. (Smith's *Historical Sketches of the Relief Church*; Hutchison's *Compendious View of the Synod of Relief*; Adam's *Religious World Displayed*, vol. iii. pp. 223–32; M'Kerrow's *History of Secession*, vol. i. pp. 319–24, 326–28.)

Relieving Tackles. Temporary tackles attached to the end of the tiller in bad weather to assist the helmsman, and in case of accident happening to the tiller ropes or wheel. The term is also applied to strong tackles from the wharf or other object, to which the ship is hove down or careened, passed under her bottom and attached to the opposite side, to assist in righting her afterwards, as well as to prevent her from oversetting entirely.

Reliquary. A receptacle for relics. The difference between a *reliquary* and a *case* (Fr. châsse) used for the same purpose is, that the former is smaller in dimensions, and contains only small fragments; the latter in many instances entire bodies.

Remainder. In Arithmetic and Algebra, the difference of two quantities, or that which is left after subtracting one from the other.

REMAINDER. In Law, a remainder is defined by Lord Coke to be 'a remnant of an estate in lands or tenements expectant on a particular estate created together with the same at one time.' It is clear that if an owner of land in fee simple conveys it to some person for an estate less than his own (as for instance for an estate for life) there will be a *remnant* of the original estate in fee simple undisposed of. If the original owner retains this *remnant* himself, it is called his *reversion*; but if he conveys it to anyone else, it is termed a *remainder*; thus if land is granted to A for his life, and after his death to B and his heirs, B is said to have a vested remainder in fee simple expectant on the death of A. The limitation of the remainder confers on B a present absolute right to the future enjoyment of the property, whenever the life estate of A (called the *particular estate*) determines; in other words, B has a *vested* estate in remainder. A vested remainder is a remainder which is conveyed or limited unconditionally, and if a remainder is not vested it is *contingent*. But a remainder may be originally a contingent remainder, and afterwards become a vested remainder; thus in the case of land being settled on A (a bachelor) for his life, and after his death on his eldest son in fee, the remainder to the son is contingent so long as A has no son; but as soon as A marries and has a son, the remainder vests in the son, and will take effect in favour of him or his representative whenever A dies. But if a contingent remainder is so limited as not to vest during the continuance of the preceding (or particular) estate (which must be in such case an estate of freehold), or as soon as it determines, it will fail altogether; thus if land is settled upon A for life, with remainder to such of his children as attain twenty-one, and he dies leaving only infant children, the remainder to the children will wholly fail, although in the case of personal property, or even in the case of land vested in trustees, such of the children as eventually attained twenty-one would take, although they might have been minors at the death of their father. The failure of the remainder in the case above suggested is a consequence of the rule that the seisin or feudal possession of land must never be without an owner, a doctrine which forms one of the first principles of English real property law, but which is now a mere technicality, fatal to many unskilful dispositions of property, but easily evaded by the expedient of vesting the land in trustees.

The creation of contingent remainders is restrained within due bounds by another rule; viz. that an estate cannot be given to an unborn person for life, followed by any estate to the child of such unborn person; for in such case the estate given to the child of the unborn person would be void; as, for instance, in the case of a limitation to A (a bachelor) for life, with remainder to his eldest son for life, with remainder to the eldest son of such eldest son in fee, the latter limitation will be simply void. [PERPETUITY.] (*Penny Cyclopædia*, art. 'Remainder;' Williams *On Real Property*.)

Remand (Lat. re, and mandare, *to commit*). In Law, the recommittal by a justice of a person charged with a serious offence to prison for a limited time, when it is necessary to postpone the preliminary examination on account of absence of witnesses or other serious cause: regulated, in England, by the Act 11 & 12 Vict. c. 43.

Remanet (Lat. *it remains*). In Law, a cause the trial of which is postponed from one sitting to another.

Remblai (Fr.). A term of Engineering, used by the French authors to express the earthwork that is carried to bank, in the case of a railway, or canal traversing a natural depression of the surface.

REMBLAI. In Fortification, the earth or materials used to form the whole mass of rampart and parapet. It may contain more than the *déblai* from the ditch. [DÉBLAI.]

Remedy (Lat. remedium). A term used at the Mint in reference to a certain *allowance* in the weight and quality or fineness of the coin of the realm. It occurs in an indenture granted by Edward VI. (A.D. 1435) to Robert Mansfield (*maître et ouvrier des monnoys d'or et d'argent en la tour de Londres et en la ville de Caleys*). It occurs again in an indenture granted in 1465 to William Lord Hastings, and is explained as follows: 'And because the said monies of gold may not continually be made according to all things to the right standard, but peradventure in default of the master and worker it shall be found sometimes too strong or too feeble in weight or in alloy, or in both, our sovereign lord the king willeth that when the said money be found at the assay before the deliverance thereof too strong or too feeble all only in weight or all only in assay or in either by the 8th part of a carat in the pennyweight of gold, which 8th part shall be called *remedy*, the money shall be delivered for good when the said default shall happen *casually*, otherwise not. If the remedy is exceeded, then the deliverance of the money is to be *challenged*, and new molten and reforged at the expense of the master.'

At present the working remedy allowed upon the pound troy of standard gold, is 12 grains as to weight and 15 grains as to fineness. Twenty troy pounds of standard gold are coined into 1,869 sovereigns, or each troy pound into $46\frac{29}{40}$ sovereigns.

Remembrancers. Officers of the Court of Exchequer, and of some corporations who

perform various functions, are so called. The office of queen's remembrancer has been regulated by various modern statutes (5 & 6 Vict. c. 86, 22 & 23 Vict. c. 21, &c.).

Remiges (Lat. *rowers*). The quill feathers of the wings of a bird, which, like oars, propel it through the air.

Remijia (after Remijo, a Brazilian physician, by whom the bark was first used). A genus of *Cinchonaceæ*, consisting of Brazilian shrubs, some species of which are called Quinas, their bark being used as a substitute for *Cinchona*. *R. ferruginea* and *R. Hilarii* are called Quina de Remijo; and *R. ferruginea* and *R. Vellozii*, Quina de Serra.

Remingtonite. A hydrated carbonate of cobalt, occurring as a thin opaque rose-coloured coating upon Serpentine, at the copper mine near Finksburg, in Maryland; and named after the superintendent of the mines.

Reminiscence (Lat. reminiscor, *I remember*). In the theory of Plato, knowledge was only a reminiscence (ἀνάμνησις) or recovery of truth which the soul had possessed in a former state of existence, but which it had forgotten since it began its sojourn on earth.

Remipeds (Lat. remus, *an oar*, and pes, *a foot*). The name of an order of Coleopterous insects, including those which have tarsi adapted for swimming.

Remission (Lat. remissio, *a slackening*). In Pathology, the abatement of a disorder, or regular mitigation of symptoms, as opposed to *intermission*, in which the symptoms of disease for a time entirely disappear. [REMITTENT FEVER.]

Remittent Fever. Any fever which suffers a decided remission in its violence during the twenty-four hours, but without entirely leaving the patient, is called a *remittent*; it differs from an intermittent because in the remittent there is never a total absence of fever. These fevers are most common in autumn, and they vary in degree from extreme mildness to alarming violence. The remittent fever of children, or, as it is often called, *infantile fever*, is now generally allowed to be typhoid fever: the tongue is very foul, the head aches, the belly is tumid, food is loathed: the child is drowsy all day, but restless and often delirious at night, and the bowels are generally very irritable. Good air, thorough ventilation, light farinaceous diet, and carefully exhibited support and stimulus usually effect cure, though the bowel affection sometimes requires the use of starch injections combined with syrup of poppies or tincture of opium. The *yellow fever*, or bilious remittent of hot climates, and especially of the West Indies, is another form of this fever: it appears to be produced by marsh miasma. In all these fevers particular symptoms occasionally present themselves, which require special modes of treatment; and this must also be modified according to the inflammatory, malignant, nervous, or intermittent form which they may assume or pass into.

Remitter. In Law, a remitter exists where he who has the right of entry in land, but is out of possession, obtains afterwards the possession of the land by some subsequent or defective title: in which case he is *remitted* or sent back, by operation of law, to his own preferable title; as, for instance, if A wrongfully evicts B, and then lets him the land (without deed) on a yearly tenancy, B on entering will be remitted to his prior and better title, though this result would not follow if he had accepted a formal lease by deed.

Remolinite. Atacamite from Los Remolinos in Chili.

Remonstrance, The. In English History, the name given to a document presented by parliament to Charles I. in November 1641. It recapitulated all the grievances which had existed since his accession. (Hallam, *Constitutional History of England*, ch. ix.)

Remonstrants. In Ecclesiastical History. [ARMINIANS.]

Remora. A genus of fishes (*Echineis*) in which the dorsal fin is so modified as to become a flattened disc covering the top of the head, composed of movable cartilaginous plates directed obliquely backwards. The fish attaches itself to a foreign body by this structure; and from this well-ascertained fact many fables have been invented regarding the genus; amongst others, one which asserts that the fish possesses the power of arresting the course of any ship to which it may have attached itself.

Remoteness (Lat. remotus, *moved back*). In Law, dispositions of property which are invalid by reason of their contravening the rule against perpetuities [PERPETUITY], are often said to be void for remoteness.

Remphan. This deity is said to have been worshipped by the Israelites while in the wilderness. The passage in Acts vii., which speaks of them taking up the tabernacle of Moloch and the star of their god Remphan, is supposed to refer to the words of Amos, 'Ye have borne the tabernacle of your Moloch and Chiun, your images.' Chiun and Remphan would on this hypothesis be the same, and both are thought to denote Sirius, the dog-star.

Renaissance (Fr.). In Architecture, a term applied to the style which sought to reproduce the forms of Greek ornamentation. This style, of which the idea had never died out in Italy, marks especially the age of the revival of letters, which immediately preceded the Reformation. It has, however, no necessary connection with the tone of religious thought which characterises the various Protestant bodies in Europe. It had taken root in Italy before Martin Luther raised his standard against the papal power; it has been retained there, although the people of Northern Europe have shown a disposition to abandon it.

The term *Renaissance* has been very vaguely applied to denote a number of styles which have but little in common. There is no doubt that in the general principle of truthfulness the first phase of Renaissance in Italy agreed closely with the Gothic styles which it sought to

supplant. In both, the ornamentation either grew naturally out of the construction, or was such as was best suited to express the uses or objects to which the building was to be devoted. We are thus supplied with a test which Mr. Fergusson, in his *History of the Modern Styles of Architecture*, has used to distinguish the one true form of Renaissance from the many spurious styles which have succeeded it. Ornamental forms, though avowedly borrowed, may be rightly applied. The Greek shaft and capital, used as a support, is as much in its right place as a Gothic pier: attached to a wall, where it supports nothing, it is put to a use for which it is not adapted, and which is therefore wrong. Hence, as soon as pieces of entablature were thrust in where they were not wanted, or columns became mere ornamental appendages, the style ceased to have a legitimate existence. This strict application of the term cuts down the true Renaissance to a very short life indeed; for the era opened with the sojourn of Brunelleschi at Rome during the early part of the fifteenth century. He returned to Florence in 1420, and died in 1444; in the interval he had erected buildings in which pieces of entablature were thrust in between the pier and arch, and so left to his successors 'the most fatal gift of classic art to modern times.' If these limits are accepted, the Renaissance, like the geometrical Gothic style, has little more than a philosophical existence.

In truth, the Renaissance architects followed the example of the older Roman builders, who disguised their genuine arched construction under forms borrowed from Greek art, or cast away that construction altogether. [ARCHITECTURE, ROMAN.] The architecture so cast aside contained the germ of the Teutonic or Gothic styles; and its abandonment by the Romans only served to check for centuries all real progress in art. But in the fifteenth century the Gothic architecture had worked itself out, and the most debased forms had been adopted long before John of Padua designed Longleat, or Inigo Jones drew out his plans for Whitehall. Hence there is nothing surprising in the fact that the countries in which the Reformation took root most firmly, were the last to take up the actual forms of Renaissance architecture. Yet the Reformation, although it cannot be regarded as the cause of the introduction of Renaissance forms into the architecture of Northern Europe, undoubtedly checked the passion for church building, which in Italy remained as strong as ever. But in Italy the Gothic forms had never been really congenial. The so-called Gothic churches of Assisi, Vercelli, and Milan had been built by northern architects. But the Renaissance architects, while casting off Gothic trammels, bestowed little thought on maintaining that truthfulness of ornamentation without which no style can have any real life. The Romanesque and Gothic styles had come into existence by casting aside the entablature from all disengaged columns (Okely, *Christian Architecture in Italy*, p. 3): the Italians of the fifteenth century felt an irresistible temptation to return to it. The former acquired strength by reverting to the genuine forms of ancient Roman construction: the latter once more placed on their necks the yoke which had crushed the native powers of the older Italian architects in the days of Cicero and Mæcenas.

The result of this adoption of an unnecessary member as a prominent form in ornamentation was a spirit of slavish copying; and in the absence of a living style applicable to all buildings, the history of modern architecture resolves itself practically into a series of biographies of modern architects. We are concerned not with the developement of principles, but with the designs of particular men; and to form a judgment of these we can make use only of certain canons of taste, in which it seems impossible to insure anything like a general agreement. We cannot decide conclusively whether the temple of Theseus is more beautiful than the choir of Cologne; but we can decide without fear of contradiction whether each of them is or is not inconsistent with the laws of construction and decoration which regulate their respective styles.

The strictly imitative character of the Renaissance is still more clearly brought out by the fact that many of the greatest buildings in this style are classical only in their details, their forms being borrowed from early Christian basilicas or Gothic and Byzantine buildings. To these forms it applied a principle of decoration which could issue only in a wearisome sameness. The Greek column was a strictly constructive feature; in Roman hands it became an appendage of a wall where it supported nothing. The Renaissance architects went a step further by employing pilasters instead of columns, and thus introduced 'one of the most useless as well as least constructive modes of ornamentation that could be adopted.' Having employed these pilasters on useless porticoes, they went on to employ them on the walls of houses, where they give no support whatever. This, in Mr. Fergusson's opinion, was a further step 'in the wrong direction; it was employing ornament for ornament's sake, without reference to construction or the actual purpose of the building; and once it was admitted that any class of ornament could be employed other than ornamental construction, or which had any other aim than to express, while it beautified, the prosaic exigencies of the design, there was an end of all that was truthful or that can lead to perfection in architectural art.' The columns thus came at length simply to indicate internal arrangement, and were separated into distinct layers by large entablatures which preclude all real unity of design. Hence resulted that exaggeration of the orders, which, as Mr. Fergusson maintains, marks the worst stage of Renaissance architecture. There is no reason why in many of the Venetian or Florentine palaces the stages should not be more in number or less; they might be multiplied without affecting the general character of the design.

The tendency to imitative forms is shown in the best specimens of the style—in the church of Lodi as in the Grimani and Guadagni palaces. On the other hand, there are some buildings which with so-called classical forms exhibit nothing of the spirit of classical art. In the church of the Annunciata at Genoa, no fragment of entablature is thrust between the Corinthian capital and the arch; while vertical lines, running up from the capital, make the space between the string-course and the cornice practically a triforium.

The general conclusion to be drawn from these facts seems to be that the Renaissance architecture is not, strictly speaking, a distinctive style, but simply a method of ornamenting forms which may be Greek, Roman, or Gothic in their character.

The practical questions involved in the subject are discussed at length by Mr. Fergusson in his *History of Modern Architecture*; while an examination of his opinions may be found in an article in the *Edinburgh Review* (for July 1864, p. 71), in which the principles of Renaissance art, here briefly sketched, are illustrated in greater detail.

Renal Glands (Lat. renes, Gr. φρήν, φρένες, *the midriff*). There is a glandular body upon each kidney, of a somewhat triangular shape, small in the adult, but of larger relative size in the fœtus; it is called the renal, or supra-renal, gland or capsule: it has no excretory duct, and its use is unknown. These ductless glands are remarkable for their rich supply of nerves from the solar plexus: in comparative anatomy they are known as the *adrenals*.

Rendered. In Architecture. [RENDERED AND SET.]

Rendered and Floated. In Architecture, plastering of three coats on brickwork.

Rendered, Floated, and Set for Paper. In Architecture, a term used to express plastering of three coats: the first being lime and hair upon brickwork; the second, the same compound, with the addition of a little more hair, which is brought to a level surface by being *floated* with a long rule; the third, fine stuff mixed with white hair, laid on with a trowel.

Rendered and Set. In Architecture, a term used to denote the plastering executed in two coats, on naked brickwork or on stonework. If the work is to be of three coats, the first of these is called the *pricking-up* coat, which is afterwards rendered and set; this is sometimes calling *roughing in*. The materials for the pricking-up coat and the rendering coat are identical; the setting coat is, generally speaking, of a finer kind of lime.

Rendezvous (Fr.). The Military term for the place appointed for the assembly of a body of troops.

Rennel's Current. An important though not very extensive current, commencing near Cape Finisterre, and running along the northern coast of Spain and the west coast of France, and so entering and crossing the English and Irish Channels to Cape Clear, whence it enters the Atlantic and is deflected again towards the south and south-east. It sets generally at the rate of about one mile an hour, and connects itself with a parallel current which flows to the north-west coast of Africa, and is therefore in the opposite direction. This latter return current proceeds along the African coast, and connects with the EQUATORIAL CURRENT. Both, no doubt, have much influence on the climate of Western Europe, but being inconsiderable in force they are liable to be much affected by modifications of the Gulf Stream.

Rennet or **Runnet** (Ger. rinnen, *to curdle*). The prepared inner membrane of the calf's stomach, which, in consequence of the presence of pepsine, has the property of coagulating the casein of milk and separating it from the whey in the form of curd.

Rensselaerite. A steatitic mineral named after Van Rensselaer. It occurs over large areas, in Northern New York and in Grenville in Upper Canada; and is, probably, identical with Pyrallolite.

Rent (Ital. rendita). In Political Economy, that portion of the produce of the soil which the competition for produce enables the owner of the soil to appropriate. Strictly speaking, rent is paid for the natural capacity or fertility of the soil only, though in popular language it is used to denote such sums as are paid for the use of capital permanently fixed in the soil, as, for instance, the draining of an estate, and the buildings which have been erected on land. Payments, however, for these conveniences or utilities are not rent, but interest or profit on capital. But whatever it be that constitutes economical fertility, whether it be the capacity of certain soils for particular crops, or the excellence of certain sites for building houses to be used either for business or pleasure, provided the capacity or excellence is due to natural causes only, the annual compensation paid for the use of these inherent advantages or conveniences is rent.

The first condition of rent is that there should be competition for the object in question. If natural fertility be unlimited in quantity, no rent can be obtained, for no one will give anything for that which he can procure at pleasure. But if the soil be appropriated, even though it may not all be tilled, rent will arise by the fact that the person or persons appropriating it have created an artificial scarcity, and so a market for natural fertility. The unenclosed and fertile lands of Australia are practically unlimited, and will be so, even with the most rapid increase of population conceivable, for centuries to come. But as the local governments, partly to prevent too great a dispersion of population, partly to create an emigration fund, have assumed the ownership of all land in the various colonies, and grant it only on payment and certain other conditions, a rent is possible, even on plots which have not had a shilling of capital permanently

expended on them. So in the middle ages and under the feudal system, all land had an owner, and therefore was made liable to rent. The rent, it is true, was low, and was extorted from the cultivator; but its origin is to be found in the appropriation of the soil, and in the necessities of the general population, who were constrained to submit to the terms imposed upon them.

Next, the produce of the soil must, by the effect of competition, be valued at a price higher than that which suffices to remunerate the cultivator for the wages of his labour and the profit of his capital. If wages be left to competition, and no attempts be made to depress them by direct legislation, the possibility of rent is postponed till such time as the demands of population raise the price of produce and lower the rate of wages. However cheap may be the cost of production, and however abundant the amount produced, no rent will be obtained till such time as the price paid for produce is greater than satisfies wages and profits. And that which applies to agriculture applies also to trade. The competition for favourable sites to be employed for trading purposes creates a rent, partly because the available area is by the very terms of a competition limited, partly because the amount of advantage in business favourable for the occupation of such sites is so much greater than could be obtained in other sites, that the owner of the soil is enabled to share in the gross profit of the business carried on in the favourite locality. The fertility of a business site is accidental, no doubt, but it is an accident which affects the land, not the business; and hence, however originated, it is of the same nature with the natural fertility of land capable of cultivation.

The modern theory of rent adopted by political economists is said to have been suggested by Anderson in 1737, but the credit of the discovery is generally shared by Mr. Malthus and Sir Edward West, the theory having been elaborated by Mr. Ricardo. It is to the effect that in newly settled countries, where abundant fertile land can be voluntarily occupied, no rent is possible; but that when, owing to the pressure of population and the demand for produce, a price can be obtained for food in excess of that which remunerates the cultivator of the best or most fertile soils, i.e. such soils as produce the largest amount of food with the least expenditure of labour, inferior soils must needs be occupied, i.e. soils on which either a less amount is produced by equal labour, or an equal amount by greater labour; and that under the circumstances, since a manifest advantage belongs to the best soils, the advantage will either, in case the ownership of the land remains with the cultivator, be covertly rent, or, in case the land belongs to one man, and the capital by which it is cultivated is supplied by another, it will appear as rent paid to the former person. In either case it will be, though entirely separate from any capital expended on the soil, available as an object of sale or mortgage.

To supply an instance in which the minimum amount of fixed capital resident in permanent improvements may be eliminated, let us suppose that there is natural water meadow on the banks of the Thames, the annual fertilisation of which is fully supplied by the natural warping of the river at the seasons of its overflow, and that consequently the only labour employed on the crop of hay consists in mowing, drying, and stacking the produce; and that the ordinary rate of produce is three tons to the acre, worth on an average 4*l.* the ton on the spot. Let us conceive also that the cost of labour, the wages of haymakers, the maintenance of horses and carts, and some other small matters, with the profit on the farmer's capital, and the remuneration which he obtains for his own superintendence and risk, amounts to 6*l.* an acre annually. Let us, on the other hand, conceive that the produce of hay on an upland pasture, which needs to be manured, dressed, and occasionally cropped, is two tons an acre, and is saleable at the same average rate, and that the aggregate charges of the labour &c. expended on the latter amount to 7*l.* 10*s.* the year per acre. The rent of the first parcel will be 6*l.* an acre, and of the latter 10*s.* If the amount of produce procured in the latter case is worth on an average no more than the charges expended on cultivating the land, no rent at all will arise, although perhaps in the total amount of land rented by a farmer a rent may seem to be paid, because the total rent is estimated by the total acreage. And the fact that all land yields a rent is not inconsistent with this view, for the rent of some parcels of land employed, for instance, as sheep-walks, is paid only because other parcels of land which must needs be let along with such sheep-walk, in order to provide winter fodder, are let at a lower rent than they would be if they were let alone, and the sheep-walk were devoted to different purposes. If we vary the instance, and take the produce of corn instead of that of hay, the result would be the same, though the conditions would be more complex.

In brief, therefore, the Ricardian theory of rent, as ordinarily understood, implies that rent has arisen from the necessity which exists for the cultivation of inferior soils, this necessity having itself been caused by the growth of population, and its demand for agricultural produce. Further, it is held that this necessity for cultivating inferior soils increases with the increase of population, and that there is no limit to the necessity put upon agricultural labour, and consequently upon rent, until the labour required to extract food from the least productive soils is to be valued at as much as the produce obtained from them.

This theory, however, appears by no means to account for all the causes which increase and diminish amounts of rent; nor will the application of the theory to certain social conditions be found either to agree with or at

least to explain many unquestionable economical phenomena. It accounts for differences in rent; and taking the facts of the great variety in the natural powers of the soil, it supplies from these data some information as to the origin of rent, and the limit at which rent is no longer obtainable. But suppose that the whole soil of a country were equally fertile, i.e. that it produced equal quantities by equal labour, and that no increase of produce were possible except by greater labour, or (what comes to the same thing) greater skill, the application of new forces, and the substitution of mechanical instead of manual labour. Would there be no rent in such a case? There certainly would be as soon as ever the demand for the produce exceeded the cost of production, i.e. immediately, for the excess of demand is, and has been, concurrently with other causes, the motive for diminishing the cost of production.

Rent appears to be the function of two variables: the cost of production, and the demand for the produce. When no demand arises in excess of supply, there is not, as in other occupations, any disposition to diminish the cost of production. When population is either stationary, or when, if it be progressive, the supply of fertile land is unbounded, the progress of agricultural science is very slow, all economy tending in the direction of the substitution of mechanical for manual labour in the latter case, and no stimulus to economy being provided in the former. It is a well-known fact that no more powerful motive to agricultural improvement has been found than in an increase of rent, and that when rents are, either by the indulgence or negligence of landlords, much lower than the possible amount procurable, land is ill or imperfectly cultivated. And the reason is obvious. Rates of profit are, equal conditions being fulfilled, equal in different occupations. But rent is whatever is produced in excess of the rate of profit. Now, as the farmer knows, or acts unconsciously on the fact, that rent is derived from this excess, he has no natural impulse to procure, except under the pressure of demand, more than the general rate of profit which will satisfy him for his capital and superintendence. But the common theory of rent always takes for granted that a diminished cost of production has a tendency to lower rents. Such an inference, however, is contrary to facts, and repugnant to the economical axiom that the rates of profit tend to an equality. The rent of arable land in the fourteenth century was *6d.* an acre on an average. The price of wheat was about *5s. 4d.* In modern weights of coin the former was *1s. 6d.* an acre, the latter was *16s.* the quarter. But the average price of wheat has risen in weight of silver about 3½ times, i.e. to about *56s.* the quarter, while the same land now lets at *30s.* to *2l.* the acre, i.e. at from ten to thirteen or fourteen times the previous rate. Yet it is absurd to say that the demand for food is greater now than it was in the fourteenth century, for agricultural labour was paid at about *3d.* a day, in other words at *9d.* of our present money, and the price of wheat as contrasted with the price of labour was disproportionately high in those ancient times. The sole cause of the increase of rent is to be found in the diminished cost of production, the correction implied by a sustained demand contributing to rent, but being a condition rather than a cause. Not only, indeed, is it not the case that diminished cost of production diminishes rent, but the facts of economical history prove the increase in rents to be due to this cause alone; and not only, again, is it not true historically that the exigencies of population have led to the cultivation of inferior soils, but it may be doubted whether the amount of land cultivated in grain crops at the present time is much more than that which was under the plough in the age referred to above, i.e. 500 years ago. The exigencies of population, concurrently with the desire of larger profits, *present and operative in those only who are at once owners and occupiers*, have led to agricultural inventions which have diminished cost and increased production, and thus rendered it possible that tenants should be forced to adopt improvements which they would never have searched for or applied as mere tenants. By these causes rents have been enhanced, and are still increasing in just the same proportion as the cost of production is diminished. Nor is rent affected by the comparative cheapness of wheat since the abolition of the corn laws. For, agricultural produce being very various, and the margin left to wages increasing when bread is cheap, the income of the labourer is larger and more available for the consumption of other products, as meat, poultry, wool, and the like.

It was not remarkable that, at the time when Malthus wrote, the partial view of the truth as regards rent should have been propounded and accepted. It must be remembered that it was a time of severe general distress, in which every economical principle was steadily ignored by the government of the day, and the expense and insulation of a great war had made it necessary that this country should depend almost entirely on its own resources for the sustenance of the people. To these circumstances must be attributed the cultivation of tracts which had not been broken up for centuries, and the activity given to the production of cereals, the rise in rents consequent upon the profits of enormous famine prices at home, and the machinery of the corn laws, intended avowedly to stereotype high prices and large rents, on the false and foolish plea of the peculiar burdens on land. Had the economists who accepted the popular view of rent, been at the pains to investigate the facts of one period of English economical history, and to contrast it with that which they knew familiarly, they would have seen cause so far to modify their theory as to have recognised the fact that rents do not fall with improvements in the process of production; they would have seen that the

interest of the agriculturist and landlord was not antagonistic to that of the general public, and would have learnt that the same rule holds good in agriculture as in trade, that the higher the profit and the less the expense of the calling, the larger is the margin left for that payment in consideration of a *locus standi* for industrial occupation which we call rent.

But while rents rise as the cost of produce in demand diminishes, they would fall if one part of the cost of production were increased, that, namely, of the wages of labour. It is true that the real rise in the wages of the agricultural labourer, which has succeeded the new poor law, and the establishment of free trade in corn, has not been attended by a fall in rents, but by the contrary phenomenon. But this result is due to the enhanced value of all agricultural produce other than wheat, and by the greater produce at less cost—circumstances which have far more than counterpoised the small rise in the rate of agricultural wages, amounting probably to not more than ten or fifteen per cent. If hereafter the mass of agricultural labourers get and use the information which might be supplied them, as to what are the only means for bettering their condition, if they could learn that early and imprudent marriages have the effect of so tying them hand and foot to their employment as to reduce their wages to the lowest point compatible with a bare existence, and that the charity of the poor rate is a very doubtful boon, they might hereafter assume a position of greater independence and hope. In the counties of Cumberland and Westmoreland, where agricultural wages reach the highest rate, the cause is to be found in the fact that the labourer is always provided with the means of emigration, and that he uses these means instantly if there be a threatened reduction of wages in his neighbourhood. Were agricultural wages increased fifty per cent. it is possible that rents would be, for a time, diminished, though the increased demand for produce would in all likelihood speedily bring about a recovery.

Rent does not raise or depress prices, as some persons have imagined, for the cause of rent and the cause of price are governed by a totally different set of facts. The price of a commodity depends on its cost, and the demand for the article; rent depends upon the amount produced on a given area, the equality of rates of profit necessitating that rent should be paid out of the excess of produce. That rents do not affect prices is manifest at once if we illustrate the fact by a supposed case. The instantaneous annihilation of rents would not cheapen food, but would simply transfer the rent hitherto paid to the landlord into the pocket of the cultivator. No one is richer or poorer because the landlord obtains a rent, for the price of produce is due to the demand for the commodity; and the general public, i.e. the consumer, is in no way interested in the distribution of the parts of that which he must needs pay by the competition of purchasers. But this general statement must be guarded by an explanation. Prices may indirectly be enhanced by the limitations or restrictions put upon the occupation of land. The general public is interested in the largest amount possible being derived from the soil, and any hindrance laid on production is therefore a national loss. For instance, if a system of long leases enabled the farmer to produce one-third more meat and corn, it is a matter of the greatest importance to the public that such a state of things should be brought about. It would be, of course, equally an advantage to the landowner, whose interests are inseparably united with the general good of the community. So if restrictions or hindrances are put upon the occupation of land for building purposes, the general public is affected because the area available for a purpose of great importance to society is artificially narrowed. Rent does not, we repeat, increase prices; but peculiar tenures of land, and difficulties put in the way of its distribution, may and do raise prices, by creating scarcity. So, again, the excessive preservation of such game as is destructive to crops is a public nuisance and a national loss.

Much greater prominence is given by English economists to the theory of rent, than is assigned to it by foreign writers. This arises from the fact that the British islands are nearly the only part of the world in which the owner of the soil and the occupier are different persons. Hence that which with foreign economists would be the question of the relation of population to the means of subsistence, is among English writers the question of the principle which governs the amount of the produce received by the owner of the soil. Of course, in effect rent is paid in other countries as well as in this, only it is under a different shape. That it is so, is manifest from the fact already adverted to, that the natural powers of the soil are as freely mortgaged or pledged in other countries as they are in this. And when land is sold, its price follows the rate of interest, being generally rather more than the capitalised value of a perpetual annuity, because it confers social rank, and is susceptible of indefinite increase in value. In foreign countries, too, the fact that the majority of the people are engaged in agriculture, enhances the cost of such parcels as are brought into the market. Rents of particular sites of agricultural land are sometimes very high, as in England of the rich hop lands of the vale of Farnham and some parts of Kent, and in France of those estates which are distinguished for the produce of such wines as bear high prices. The best French vineyards are frequently sold at the rate of a thousand pounds an acre; and of course if such vineyards were let, they would bear a corresponding rent.

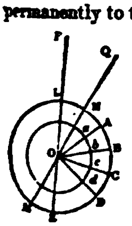
Rents in other countries than this are of many various kinds. For an account of each, see COTTIER, CONACRE, LABOUR RENTS, MÉTAYER, SERF, and RYOT. For the effect of a tax on rents, see TAXATION.

Besides the attention which has been given to rent by such writers as have discussed the principles of political economy, special pains have been taken with this subject by Malthus, Ricardo, and Jones. No modern economist has devoted more pains than the last-named writer to the general theory of rent, and to the various forms in which rent appears. The views of Mr. Jones are to be found in his work on Rent, and in his literary remains, which have been collected by Dr. Whewell.

Repeat (Fr. répéter, Lat. repeto). In Music, a character 𝄋 denoting the repetition of the part which it bounds. It is sometimes expressed by dots against the bar, and sometimes by the words *dal segno*.

Repeating Circle. In order to diminish the effect of errors of graduation, and to obtain very accurate measurements by means of comparatively small and therefore portable instruments, a method of observing was invented, or rather brought into use, by Borda, which is now extensively employed, especially in geodetical operations. The method, which consists in moving the telescope successively over portions of the graduated limb corresponding to the angle to be measured, and reading only the multiple arc, may be advantageously applied to circular instruments destined for very different purposes; as, for example, to an instrument for the measurement of the zenith distances of stars or terrestrial objects, or the distance of two trigonometrical stations, in which case it is simply called a *repeating circle*; to a reflecting circle used for observations at sea, when it becomes a *repeating reflecting circle*; or to a theodolite, when it becomes a *repeating theodolite*.

For the purpose of giving an idea of the principle of this method, we borrow the following illustration from Sir J. Herschel: 'Let P Q be two objects, which we may suppose fixed for purposes of mere explanation; and let K L be a telescope movable on O, the common axis of two circles, A M L and A B C, of which the former, A M L, is absolutely fixed in the plane of the objects, and carries the graduations freely movable on the axis. The telescope is attached permanently to the latter circle, and moves with it. An arm, O *a* A, carries the index or vernier, which reads off the graduated limb of the fixed circle. This arm is provided with two clamps, by which it can be temporarily connected with either circle, and detached at pleasure. Suppose now the telescope directed to P. Clamp the index O A to the *inner* circle, and unclamp it from the outer, and read off; then carry the telescope round to the other object Q. In so doing, the inner circle, and the index arm, which is clamped to it, will also be carried round over an arc A B on the graduated limb of the outer circle equal to the angle P O Q. Now clamp the index to the *outer* circle, and unclamp the inner, and read off. The difference of readings will, of course, measure the angle



P O Q; but the result will be liable to two sources of error, that of graduation and that of observation, both of which it is our object to get rid of. To this end transfer the telescope back to P, *without* unclamping the outer circle; then, having made the bisection of P, clamp the arm to *b*, and unclamp it from B, and again transfer the telescope to Q, by which the arm will now be carried with it to C over a second arc B C equal to the angle P O Q. Now again read off; then will the difference between this reading and the *original* one measure *twice* the angle P O Q, affected with both errors of observation, but only with the same error of graduation as before. Let this process be repeated as often as we please (suppose ten times); then will the final arc A B C D read off on the circle be ten times the required angle, affected by the joint errors of all the ten observations, but only by the same constant error of graduation, which depends on the initial and final readings off alone. Now the errors of observation, when numerous, tend to balance and destroy one another: so that, if sufficiently multiplied, their influence will disappear from the result. There remains, then, only the constant error of graduation, which comes to be divided in the final result by the number of observations, and is therefore diminished in its influence to one-tenth of its possible amount, or to less if need be.' ('Astronomy,' *Cabinet Cyclopædia*, p. 105.)

When the repeating circle is used for measuring zenith distances, it is constructed so as to be capable of being turned round on a vertical pivot, the direction of which passes through its centre, and to which its plane is parallel, and also of turning in its own plane about a horizontal axis. The instrument being placed in the same vertical plane with the star, the telescope is directed to the star and the bisection made; the telescope, which carries the verniers with it, is then firmly clamped to the circle, and the circle turned round 180° in azimuth about the vertical pivot. If the circle be now kept fast, the telescope unclamped and carried round till the star is again bisected, it is plain that the arc of the limb passed over by the verniers in consequence of this motion of the telescope will be double the zenith distance of the star. The same process is repeated as often as may be thought necessary. For the purpose of geodetical measurements the circle is usually furnished with two telescopes, one on the face, and the other on the back; and so placed that the optical axes of both are exactly in the plane of the circle. The circles used by Mechain and Delambre, in the operations connected with the measurement of the French arc of meridian, were about four-tenths of a mètre (nearly 16 in.) in diameter, and were divided into arcs equivalent to about 32 sexagesimal seconds, which were subdivided into tenths by the verniers.

The merit of first applying the ingenious principle of repetition to angular measurements belongs to Tobias Mayer; but it was Borda, as above stated, who first brought the instrument into general use.

For a description of the repeating circle, its adjustments, and the method of using it, see Biot, *Astronomie Physique*, tome i.; Delambre, *Astronomie*, or *Base Métrique*, tome i.; Puissant, *Traité de Géodésie*; Raper's *Practice of Navigation*, &c. The comparative advantages and defects of the instrument are very clearly stated in a paper by Troughton in the first volume of the *Memoirs of the Royal Astronomical Society*.

Repellents (Lat. repello, *I drive back*). Applications to the surface of the body which appear to make disorders retreat inwards.

Repelling Power. [REPULSION.]

Repent (Lat. repens, part. of repo, *I creep*). In Botany, a term applied to stems which lie flat upon the ground, and emit roots from their under surface.

REPENT. In Zoology, this term is used in the same sense as creeping, and is applied to those animals which move with the body close to the ground, either without the aid of legs, or by means of more than four pairs of short legs.

Repetend (Lat. repetendus, part. of repeto, *I renew* or *go over again*). In Arithmetic, a term sometimes used to denote the part of a circulating decimal which is continually repeated.

Repleader. In Law, repleader is awarded in some cases when, after issue in an action is joined and verdict given thereon, it is found that by mistake issue has been joined on a fact totally immaterial and insufficient to determine the right, so that the court upon the finding cannot know for whom judgment ought to be given. In such case the court will sometimes award a repleader (quod partes replacitent), the effect of which is that the pleadings begin again de novo at that stage of them in which the error happened. [PLEADING.]

Replevin. In Law, an action of tort, in which the plaintiff seeks the recovery of goods illegally distrained. Since 19 & 20 Vict. c. 108 the proceedings can be commenced in the county courts. [ACTION.]

Replication (Lat. replicatio). In Law, the third stage in the pleadings in an action, being the plaintiff's answer to the defendant's plea. [PLEADING.]

Replum (Lat.). In Botany, a term applied to the frame left in certain fruits by the falling away of the valves, as in the siliques and silicles of the *Cruciferæ*.

Reports (Lat. reporto, *I bring back*). In Law, statements of adjudged cases in the several courts of law and equity which form precedents for future decisions. In earlier times the reports were published by authority, but this series (which is known by the name of the *Year-books*) was discontinued in the reign of Henry VIII., since which period the compilation and publication of the authoritative decisions of the courts has been conducted by private persons on their own responsibility. An attempt to restore official reporting was made by Lord Bacon, and an ordinance to that effect was obtained from James I.; but only one reporter, Hetley, seems ever to have been appointed under it. The place of the year-books was, however, soon supplied by other reports. These at first were merely notes of adjudged cases taken by lawyers for their own use, and published long after the cases were decided. There seems to have been a doubt, which (as appears from the preface to Sir James Burrow's reports) was subsisting so recently as 1765, whether the unauthorised publication of the daily proceedings of a court of justice might not be a contempt of court. Contemporaneous reports of the decisions in all the courts have, however, now been regularly published for a great number of years. The volumes of reports amount at present (1866) to nearly 1,200 in number, and the yearly increase lately has been from twenty to thirty volumes. Up to the close of 1865 the decisions in every court were separately reported in a regular series; but besides the regular reports of each court there were five or six legal publications, coming out weekly or monthly, and professing to give reports of the decisions in all the courts. The latter publications are sometimes termed *unauthorised reports*, in distinction from the regular or authorised reports; but in fact the regular reports possess no special privilege or authority except that some judges have viewed them with more favour than other reports, and given their authors occasional assistance in the way of lending written judgments, revising proof-sheets, and the like. It is, however, understood that any report of a case published with the name of a barrister annexed to it is accredited, and may be cited as an authority, although as a matter of practice the regular reports (as having been published with greater care and deliberation) are usually cited in preference to the other reports when the same cases appear in both. All the reporters have reported or omitted such cases as they respectively thought fit without control from any superior authority, and it has frequently happened that the reports have been some years in arrear. The cost of taking in the reports has formed a serious item in the professional expenses of every barrister, several of the competing series having usually been taken lest any case should be overlooked.

An attempt has recently been made on the part of the bar to procure the consolidation of the regular reports into a uniform series, to be published at a reasonable price, under the supervision of competent editors and the general superintendence of a council selected from the leading members of the legal profession; and this movement seems likely to be successful in removing the principal evils attending the system of law reporting as hitherto conducted.

Repose (Fr. repos, from Lat. repono, *I lay down*). In the Fine Arts, the absence of that agitation which is induced by the scattering and division of a subject into too many unconnected parts, in which case a work is said to want repose. Where repose is wanting from this cause, 'the eye,' says Sir Joshua

Reynolds, 'is perplexed and fatigued, from not knowing where to rest, where to find the principal action, or which is the principal figure; for where all are making equal pretensions to notice, all are in danger of neglect.'

Repose, Angle of. In Engineering, the term *angle of repose* is frequently applied to express the angle at which the various kinds of earth will permanently stand, when abandoned to themselves. The knowledge of the limits of this angle will be found essential to the engineer who is charged with the execution of large cuttings, or embankments, or who may have to execute retaining walls, or other structures of a like nature. The reader who may desire to study this question in detail, is referred to Rondelet, *L'Art de Bâtir*; to Mayniel, *Traité de la Poussée des Terres*; to Barlow's *Essay on the Strength and Stress of Timber*; Pasley's *Course of Military Instruction*; and to Parnell's *Treatise on Roads*. It appears, from the authors cited, that the earths mentioned below will stand at the angles quoted opposite to them, if only they be of an even nature and without intermixture of strata that would give passage to the waters. It is for this reason, the probability, namely, of the occurrence of a mixture of sand with the general body of the formation, that in practice it is safer to count upon the various earths standing at the angles quoted against them.

Nature of Earth	Angle	Slope of Base to Height
Fine dry sand, of pulverised sandstone	$34\frac{1}{2}°$	about $1\frac{1}{2}$ to 1
Ordinary earth, dry . . .	46·50°	
Ordinary earth, lightly wetted .	54°	
Shingle, comparatively speaking dry	49°	
London clay, very variable, much sand	. .	3 to 1
Chalk, or chalk marl . . .	. .	1 to 1
Sandstone, firm, hard, and uniform	. .	$\frac{1}{2}$ to 1
Limestone	. .	$\frac{1}{4}$ to 1
Granite, or the primary rocks .	. .	$\frac{1}{8}$ to 1

Generally speaking, it is considered safer to make the slopes of all new embankments $1\frac{1}{2}$ in base to 1 in height, excepting where they are executed in clay, which is thrown out with a slope of 2 to 1 as a minimum. The slope which the earthwork would assume at the back of a retaining wall of a river will be always affected by the infiltration of the water from the river, which will mount up in the pores of the material by capillary action. Hence the actual thickness given to retaining walls is much greater than that which the theory demands. Having to resist, in fact, the thrust of a substance which is a semifluid heavier than water, they are usually made of half their height in their average thickness. [Quay Wall.]

The term *angle of repose* is also used, in works upon Mechanics, to express the angle at which the effect of gravity is capable of overcoming the friction which the relative surfaces of the bodies in contact exercise on one another; or, in other words, the angle at which those substances would begin to move, as in an arch, it being supposed that each of them is homogeneous, and that its particles are incapable of moving one over the other. This may be calculated at about 60° from the perpendicular to the horizon; but very much will depend upon the adhesion of the cement employed between the stones or bricks that enter into the composition of the arch; so much so as in fact to render all abstract reasoning with respect to the stability of arches executed in small materials and cement utterly valueless. The conditions of the stability of an arch will be found discussed in Moseley's *Engineering and Architecture*, or in Claudel's *Formules à l'Usage des Ingénieurs*.

Representation (Lat. repræsentatio, from præsens, *present*). In Painting and the other Arts, the transference to a plane of a solid mass, or the appearance of an object to the eye.

Representation. In Politics, that machinery in the system of government by which one person or a few persons are made the vehicle in expressing the opinions of a large number, with a view to action on those opinions. It is generally understood that a *representative* fulfils different functions from a *delegate*; that while the latter is empowered to carry out only a defined and distinct purpose, the former is intrusted with a general power of judgment within certain limits; that he is entitled to exercise a discretion on subjects which may become topics for political debate from time to time; and that, while he is bound in good faith to adhere to the general principles of the party or aggregate of persons for whom he speaks, he is allowed a considerable latitude of judgment, subject, of course, to the ultimate approval or condemnation of the constituents for whom he acts. Some parallel may be found in the position occupied by a plenipotentiary in diplomacy, as contrasted with that of a chargé d'affaires, or a minister with limited powers.

It is clear that the institution of a representative system must be the result of a long series of events, in the course of which it has become possible that a trust may be committed to the representative, and confidence may be reposed by the constituents. The representative system in politics has arisen from an elaborated political education of the people, by which checks upon itself and its representatives have been gradually developed, which are not indeed capable of exact definition, and are, under the pressure of occasional emergencies, shifting, but which are withal real and reciprocally comprehended. The interpretation of these obligations is facilitated by that *government by party* which is justly considered to be intimately connected with representative institutions. The general traditions of political parties are in ordinary cases a rough guide to the duty imposed on a representative; and, as a rule, a departure from the principles of the party which returns its representative, is held to be a breach of trust and an act of political immorality or perfidy. The more marked is

that departure, the more just is the criticism on the conduct, and the more necessary is apology or explanation for the action of the offender.

The political systems of the ancient world contained no theory of representation. Faint traces, it is true, of such an expedient, may be discovered in the action of the Amphictyonic council, especially in the later days of its existence, when it was rapidly being turned into an engine for the aggrandisement of the Macedonian kings. Some slight indications of representation, too, may be traced in the Ætolian and Achæan leagues; but in all these cases the powers of the federation are rather those of delegates instituted for a particular purpose, and bound to very narrow and definite functions, than of representatives who could originate a policy or deal with an emergency. For the Greeks, Mr. Grote has well remarked that 'in respect to political sovereignty, complete disunion was among their most cherished principles. The only source of supreme authority to which a Greek felt respect and attachment, was to be sought within the walls of his own city. . . . . Political disunion—sovereign authority within the city walls—thus formed a settled maxim in the Greek mind. The relation between one city and another was an international relation, not a relation subsisting between members of a common political aggregate.' (*History of Greece*, part ii. ch. ii.) Hence all transactions between one city and another can be characterised only as *interpolitical*, and the theory of a state or city implied the competence of all the citizens to take part in the government. [LIBERTY; PRIMARY ASSEMBLIES.] Thus no room was left for the modern notion of representation, and hence the attempts to turn Hellenism into a real political unity and a basis for joint operations were abortive, because the requisite machinery for joint action was wanting, and could not have been developed without long training and a number of concessions which the several states were not competent to understand, or, if competent, willing to endure.

Still less was the Roman system representative. The whole people, it seems, was summoned to give effect to certain laws, and to elect magistrates. But the executive and legislative body of ancient Rome, though derived originally from popular election, ceased, after the election was over, to be representative, because it ceased to be responsible to the electors. The Roman senate, from whom in practice the laws emanated, and to whom the administration of public affairs was intrusted, was in effect a chamber of life peers, the introduction to which chamber was accorded to all who had held particular public offices. Only a faint trace of representation is, perhaps, discovered in the influence exercised by the *tribus prærogativa*. Shortly after the institution of the empire, popular elections became a complete farce; the custom of summoning the electors fell into disuse, and was speedily abolished.

The system of representation peculiar to the western nations of Europe had a very humble origin. Historically, it is in all likelihood an imitation of the representative assemblies of the clergy, among whom, for obvious reasons, the practice of delegating certain members of the body to speak for the whole, in general and local councils, was early adopted. But as far as regards assemblies of the laity, it appears that the origin of the modern system is to be found in the fiscal necessities of the sovereign.

At about the commencement of the thirteenth century, an important change was being effected in the social condition of the people by the gradual creation of chartered towns. These towns had purchased freedom from arbitrary taxation or tallage, with the right of holding local courts of law, and of electing municipal magistrates, from the lords on whom they had previously been dependent. For various reasons they were favoured by the monarchs; and these towns grew in wealth and importance in England and France, but especially in Spain. They formed a counterpoise to the power of the feudal barons; and the protection which the king was able to accord them, was largely and gratefully repaid by grants of subsidies and other pecuniary aids.

The mechanism by which these aids were accorded to the sovereign consisted in the appointment of two burgesses or two knights, whose business it was to make the grants, and probably to assess the contribution. As they were virtually transacting business for their constituents, they were allowed wages; and as they were supposed to be acquainted with the circumstances of the town for which they appeared, they were generally selected from the residents in the town. When in course of time it became an object of some ambition, and perhaps (in consideration of the wages paid) of advantage to sit for boroughs in parliament, an attempt was made to limit the election to such as resided in the represented borough; but the Act fell speedily into desuetude, if indeed it was ever acted on.

The settled principle of constitutional law, that no tax could be levied without the consent of the taxpayer, originally affirmed in the Great Charter, and perpetually confirmed by renewals of the charter, and the practice of government, made the frequent summons of these parliaments necessary. The demands of the monarchs almost necessitated the license of debate, at least on the grounds for which the grant was required. On this right of debate followed the right of petition, of the concession of the prayers contained in these petitions, of the embodiment of such petitions as were conceded in a formal statute, and ultimately of the power of originating statutes. Nor can it be doubted that as these appeals to the crown formed, soon after the regular summons of parliaments, a large portion of their business, the local representatives were from early times intrusted with the duty of making these petitions, and that there was some preliminary discussion in the municipal bodies as to the

terms in which petitions should be presented, and as to the claims which should be made in consideration of the grants accorded to the king. The events, then, it may be repeated, under which the representative system has been developed are so numerous, and have been so continuous, that the method now elaborated in this country and in others which have sprung from it is the result of a political education extended back into the history of nearly six centuries, a slow and steady growth of national habit.

From a variety of causes, too numerous to be noticed in an article like the present, increasing importance was annexed to the office of a parliamentary representative from as early a date as the middle of the fourteenth century; and by implication the relations of the member of parliament to his constituents, though never formally defined, have become more precise and intelligible. Considerable safeguards to an abuse of the power possessed by representatives are found in the right of public meeting, in the criticism of the local and metropolitan press, and in the practice, now become general, in boroughs at least, that during his tenure the member should meet his constituents and explain his action on points of public policy.

As the origin of the representative system is to be found in the necessity laid on the monarch of appealing to the people for aid in his fiscal exigencies, so it was the policy of the kings to accord the privilege of parliamentary representation to all towns in which any trade or manufacture was carried on. Hence the representation of the boroughs was far more copious than that of the counties, all of which latter sent two members, and two only. It is certain that in early times, at least, the towns which were admitted to the borough franchise had some local importance. Thus the Cornish towns were important for their trade in metals, especially in tin; the Dorsetshire and Wiltshire boroughs were the local centres of the cloth trade; those of Surrey and Sussex were marts for manufactured iron, at that time chiefly produced in the south of England; and so on. In course of time the trade migrated, and the towns declined. The power hitherto assumed by the king of creating new boroughs by charter was checked at the beginning of the reign of Charles I.

In course of time many of these boroughs sank into complete decay, while others not represented in parliament grew into great cities. Thus, while Birmingham and Manchester sent no members, Old Sarum and Gatton, which had actually ceased to exist, sent two members apiece. Again, the right of suffrage was in many cases shared by a few persons, or even monopolised by an individual. Thus during a part of the eighteenth century one person sent both members for the borough of Helston. Many of these anomalies were remedied by the Reform Act of 1832, which, although an affair of compromises, may be held to have recognised to a limited extent the principle that population, taxation, and representation should be relative, and certainly made it impossible that there should be any final settlement of the representative system, as long as there is any discrepancy between the proportions in which these political conditions stand to each other.

The theory that representation should be based on numbers, when once the tradition of a permanent right to send members from any given place (whether large or small) was invaded, is logical and ultimately inevitable. As long as the privilege of the ancient boroughs was respected and maintained, it was possible to vindicate on certain grounds, whatever they were worth, the system of nomination, or as they were called, more familiarly (for party names are seldom elegant or courteous), rotten boroughs. But when once the defence was forced, though it might still be possible to delay the capitulation, the maintenance of any other representative theory than that which is based on numbers became a mere question of time, and the surrender, if the representation is a matter of public interest (i. e. of that interest which is essential to national vitality), was felt to be scientifically necessary. It is needless to say, that this necessity is quite distinct from any theory as to what should constitute the franchise or right of voting. In other words, that which is called the *redistribution of seats* is one thing, the *extension of the suffrage* is another. The latter may be a matter of debate, the former can be delayed only by the force of particular influence. [SUFFRAGE.]

Of late years the theory of representation in parliament has been coupled with some other questions; and first as to the best means of giving effect to the opinion of the minority. This question presupposes two postulates, universal suffrage and numerical representation. As long as there exists an unequal value in the votes given by electors, so long is the numerical minority represented in the return; and similarly, as long as any person of competent age and education, who is not chargeable with crime, and not a claimant for a public maintenance out of poor rates, is excluded from the franchise, so long the social minority is more than adequately represented. Hence the theory of representing minorities, in the hands of its ablest advocate, Mr. Mill, includes by logical necessity the representation of women.

The means by which it is suggested that minorities may be represented are generally two. One of these is that of giving two votes to each elector when three candidates can be returned, or one vote when two are to be elected. Such a system has been adopted in the election of the several members who constitute the council in the university of Oxford. It certainly secures that the minority should appear in the governing body, and that the views entertained by such a minority should gain a hearing in debate. But of course it does not secure more than a hearing. The

action will still be directed by the majority, and the hearing might be just as effectual outside as inside the deliberative body.

Another method, suggested by Mr. Hare and supported by Mr. Mill, is that which gives the elector an option in choosing the constituency in which to record his vote. Here it is manifest that the conditions adverted to above, viz. universal suffrage and numerical representation, must be conceded in order to give the plan even the appearance of fairness. If an elector could choose his own constituency, and if constituencies having equal numbers of representives varied in size, it would be possible by transferring votes to the smaller constituency to give the minority the power of a majority.

It may be doubted, however, whether the disadvantages supposed to affect a minority are not rather apparent than real. No one intends, we may suppose, to give a minority more than a fair hearing and a right of protest. But this appears to be effectually accorded by the machinery of an election, and still more by the abundant means, under the conditions and conveniences of modern civilisation, which exist for the promulgation of political opinions through the press and by public meeting. There seems to be no disposition on the part of the majority to oppress the minority; on the contrary, the course of history indicates that the reverse process has been generally exhibited, and that governments have frequently subsisted on active and well-organised minorities.

The chief objection to the parliamentary representation of minorities (of course they are invariably present in parliament by indirect means) is that it takes away from the electors the disposition to political debate, and tends to insulate political opinion from the healthy atmosphere of competition. If an elector is empowered to register his vote in a locality which accepts his opinions as foregone conclusions, he will be at no pains to interpret these opinions by any other standard than that of his own prejudices. This is in itself an evil. Besides, it may be urged, that of all kinds of education, that which cultivates the reflective and logical faculties is the most valuable, and that to the mass of men no set of facts is more available for this culture than debate on such large questions of political, social, and economical interest as are and will be the objects of parliamentary judgment and action. Furthermore, it is of no small value and of no little economy to government and to parliament that such questions should be ventilated out of doors, and perhaps no better means could be devised for the complete cessation of such a contest of opinion as is implied in general debate, than the concession of the privilege of recording a vote in quarters which would leave the question undebated, because virtually settled. Lastly, it would throw the whole onus of argument on parliament and the press, would tend to make the decision of the former more difficult and more slow, and would exaggerate that special evil of our own time, the disposition on the part of the general public to accept, as a relief from the trouble of thinking, the irresponsible expression of anonymous political writers, the special pleading of the worst kind of advocates.

Representation of Classes.—Some modern political writers, among whom we may quote Lord Grey, have advocated the view that certain constituencies should be so arranged that the members of parliament from them should represent certain interests. In this way it is supposed that the various interests would get a fair hearing, and that parliamentary action would be facilitated. Such a representation does exist to a limited degree in the members for the universities. It may be added that the parliamentary constitution of Sweden is entirely in accordance with this principle.

It may be feared, however, that such an expedient would defeat its own ends. Parliament, if it fulfils its duty, exists in order to harmonise, not to stereotype and insulate classes; to deal with common interests, not to be split up into juntos which shall watch over particular interests. At the present time, and under its existing constitution, the commonest reproach against parliament is, that in addition to the two great divisions inseparable from the system of political action, those which have been called the party of progress and the party of order, the House of Commons has an infinity of subordinate parties. Thus, we hear of the Railway party, the Irish party, the Catholic party, the landed interest party, &c. Now if this division is an evil, why add to it? Still more, why turn an acknowledged hindrance, whose existence is indirect, into the machinery of the constitution, to be invested with a direct and recognised existence? The acceptance of such a scheme would probably involve inconceivable confusion, and bring matters rapidly to a dead lock.

Representation by Accumulation.—In trading companies, the possessor of the larger amount of shares has generally a proportionate amount of votes. It has been argued that the same rule should be extended to political interests, and that the possessor of large property, having a larger interest than he who has little, should be endowed with larger influence in the conduct of government. Such a theory, in the first place, accepts the position that property or wealth is comprised in material objects only, a position which is certainly open to dispute. It further takes for granted that the sole object of government is the preservation of property, whereas it is just as much, perhaps even more, concerned in the preservation of that order by which life and its lawful enjoyments are secured and labour is exercised. It may be doubted, too, whether under the most democratic form of government conceivable, property would not exercise a large proportionate influence on public action and policy. Wealth represents, among other objects, the sum of desirable

things; and, coupled with the disposition to procure and admire such things, there exists, in modern society at least, the conviction that the only means by which these objects can be obtained and protected, lie in the fullest freedom of action and the largest possible defence to property.

It is impossible in so wide a subject as that of the present article, to do more than summarise the question; and it is wholly impracticable to attempt a selection from the vast mass of literature which has grown up around it.

Reprieve (from Fr. reprendre, *to take back*). In Law, the suspension of the execution of sentence on judgment in a criminal case for a certain time. Reprieve at the will of the judge is arbitrary; and the judge has power to give it where he is dissatisfied with the verdict, in order to give time to apply to the crown for a pardon. Reprieve is also ex necessitate legis; as, a woman capitally convicted has a right to a reprieve during pregnancy; or when a party becomes insane between judgment and award of execution.

Reprisal. In National Law, reprisal is the capture of property belonging to the subjects of a foreign power in satisfaction of losses sustained by a citizen of the capturing state. [MARQUE.] Letters of reprisal are grantable by the law of nations, where the subject of one state has been oppressed or injured by the subjects of another, and where justice has been refused on application by letters of request. The mode of serving out letters of marque and reprisal in time of truce was regulated by stat. 4 Hen. V. c. 7, but this has been long disused. The power of granting letters of marque and reprisal has been given by statute, and sometimes by proclamation, to the lords of the Admiralty. [PRIVATEER.]

Reprises (Fr. reprise). In Law, deductions or payments out of the value of lands, such as rent charges or annuities.

Reprobation (Lat. reprobatio). In Theology, a term commonly applied to the supralapsarian tenet of the consignment of all mankind to eternal punishment, with the exception of those whom God has arbitrarily selected for eternal happiness. [ELECTION; PREDESTINATION.]

Reproduction (from Lat. re, and produco, *I draw forth*). In Physiology, this word is sometimes used for *generation*; but it signifies properly the power which a fully developed organised being possesses to push forth and form anew parts of the body which have been cut off. Vegetables possess this faculty in an eminent degree, and animals have the power of reproduction in proportion as they resemble vegetables in the simplicity of their organisation; thus the freshwater polype *Hydra viridis*, when divided into many pieces, reproduces all its characteristic organs out of each piece. Worms and other Annelides can reproduce many segments of the body. Snails can push forth new horns, and reproduce even a great part of the head. Lobsters and spiders thus gain new claws or legs. Newts and lizards reproduce their tails.

Reptation (Lat. reptatio, *a crawling*). A mode of progression by advancing successively parts of the trunk, which occupy the place of the anterior parts which are carried forwards, as in serpents. The term is also applied to the slow progression of those animals whose extremities are so short that the body touches the ground.

Reptiles (Lat. reptilia, from repo, *I creep*). The name of a class of cold-blooded Vertebrate animals, including all those which have lungs, and a heart composed of two auricles and one ventricle. Those which retain their gills during the whole or a part of their existence are termed *Batrachians* or *Amphibia*: the latter name Linnæus applied to the whole group, as well as to certain true fishes [AMPHIBIANS; BATRACHIANS; CHELONIANS; OPHIDIANS; SAURIANS.] Cuvier, in characterising the class of reptiles as defined by him, well observes, that as it is from respiration that the blood derives its heat, and the muscular fibre its susceptibility of nervous irritation, the blood of reptiles is cold, and the muscular energy less than that of quadrupeds, and much less than that of birds. Thus we find their movements usually confined to crawling and swimming; for though at certain times several of them jump and run with considerable activity, their habits are generally lazy, their digestion excessively slow, and their sensations obtuse. In cold or temperate climates, almost all of them pass the winter in a state of torpor. Their brain, which is proportionally very small, is not so essentially requisite to the exercise of their animal and vital faculties as to the members of the first two classes: their sensations seem to be less referred to a common centre, for they continue to live and to exhibit voluntary motions long after losing their brain, and even after the loss of their head. A communication with the nervous system is also much less necessary to the contraction of their fibres, and their muscles preserve their irritability after being severed from the body much longer than those of the preceding classes: their heart continues to pulsate for hours after it has been torn away, nor does its loss prevent the body from moving for a long time. The blood-discs are elliptic and nucleate, and relatively larger than in fishes. Batrachians show a marked difference from plagiostomes in this particular.

The smallness of the pulmonary vessels, and the relations of their trunk to the heart, permit reptiles to suspend the process of respiration, without arresting the course of the blood; thus they dive with more facility, and remain longer under water, than either the Mammalia or birds.

Few reptiles hatch their eggs: still fewer bring forth living young. The Batrachians on quitting the egg have the form and branchiæ of fishes, and some of the genera preserve these organs even after the developement of their lungs.

The quantity of respiration in reptiles is not fixed, like that of the mammals and birds, but varies with the proportion of the diameter of the pulmonary artery compared to that of the aorta. Thus tortoises and lizards respire more than frogs, &c.; and hence a much greater difference of sensibility and energy is manifested in this class than can exist between one mammal and another, or between birds. [HERPETOLOGY.]

Republic (Lat. respublica, *commonwealth*). That form of government in which the supreme power is vested in the people. A republic may be either an aristocracy or a democracy: the supreme power, in the former, being consigned to the nobles or a few privileged individuals, as was formerly the case in Venice and Genoa; while, in the latter, it is placed in the hands of rulers chosen by and from the whole body of the people, or by their representatives assembled in a congress or national assembly. The free towns of the Continent, Hamburg, Frankfort, Lübeck, and Bremen [HANSA], are instances of this latter form of government, as are also the United States, and some of the South American confederations. France has twice declared itself a republic, and each time the republic has been displaced by an empire. [FEDERAL GOVERNMENT; PRIMARY ASSEMBLIES; SLAVERY.]

Republication of Wills. In Law, an avowed renewal of a will; as by codicil. [WILL.]

Repudiation (Lat. repudiatio, *a rejection*). It has sometimes happened that an administration has formally declined to be bound by the debts of the governments which have preceded it; it has frequently happened that administrations have neglected to pay interest on debts which have been contracted. The former of these acts is called *repudiation*. It is said by Hallam that when the old Pretender landed in Scotland in 1715, he was ill advised enough to throw some doubt, in one of his proclamations, on the obligation of the national debt, and that consequently even those of his own party among the moneyed classes were discouraged from giving him any assistance. There is hardly a single European state which has not either annihilated a portion of its debt, or converted it into a lower denomination, or liquidated over issues of government paper by creating a capital stock on which interest was to be paid according to the metallic value of its issues at the time of their conversion into stock.

Repudiation proper, i. e. the distinct disavowal of public obligations, has been practised by several of the states composing the American Union, the most shameless examples of these acts having been exhibited by the states of Mississippi and Pennsylvania. By the peculiar constitution of the American Union great facilities were afforded for such violations of public faith, for there was no police by which the acts of these communities could be coerced. For many purposes, as for borrowing money, the states are independent; in one particular among others, that, namely, of their relation to foreign governments, they act in union. But no means could be devised by which the liabilities of the state could either be shifted upon the central government, or indeed by which the finance of the state could be controlled by the general public administration. State rights enabled the communities to borrow, and state rights precluded the foreign creditor from any remedy.

Of course no direct means can ordinarily be employed to compel the liquidation of debts contracted by foreign governments, if they resolve to be dishonest. But there is a very powerful indirect means in the prohibition of any quotation of their securities on foreign state exchanges. As every administration is occasionally liable to the necessity of borrowing, a default at any period of its financial history is at once a public scandal and a serious source of financial embarrassment when the exigency arises.

Repulsion (Lat. repulsio, *a driving back*). A term sometimes applied to the force or agency which prevents particles of matter from coming into contact. That such particles are not in absolute contact is proved by many experiments. Thus, in many cases, given volumes of two different fluids form, on mixing, a volume less than the sum of the two volumes when separate; a fact explained only by supposing that the particles of the fluids have approximated more closely to each other, and therefore that before mixture there must have been more space between those particles than existed after mixture. Again, nearly all substances contract in bulk on cooling, a phenomenon evidently due to the withdrawal of a certain amount of repulsion. Newton strongly pressed a spherical mass of glass on the flat surface of a mirror, and proved that even then the two were not in contact, and that the distance between them was not less than the eighty-nine-thousandth of an inch.

Requa Batteries. An arrangement of gun-barrels somewhat similar to the *ribaudequin* of the middle ages, from which the name appears to be derived. They were much used in the attack upon Charleston by the Federal troops under General Gillmore in 1863. The following description is extracted from the report of Major Brooks, assistant engineer in those operations:—

'This rifle battery is a device for multiplying and accelerating infantry fire from rifle barrels, and appears in principle to be a substitute for a six-pounder field-gun whenever grape and canister are needed, and, to the extent of its range, case shot, over each of which it possesses greater precision and much less liability to fail in producing desirable results.

'It consists of twenty-five rifle barrels, each twenty-four inches long, arranged upon a horizontal plane and held in position upon a light field carriage by an iron frame. Upon this frame, in the rear of the barrels, is fitted a sliding bar worked by two levers (one at

each side), by which the cartridges are forced to the rear of the chambers. By a lever under the frame the barrels may be diverged so as to scatter the balls 120 yards in a distance of 1,000. The weight of the battery, complete, is 1,382 pounds.

'When served by three men, the battery is readily fired seven volleys, or 175 shots, per minute. It did not foul. Nine degrees elevation gave a range of 1,200 yards, at which distance, the barrels being diverged, the shot scattered into an effective line. Thirteen hundred yards is probably its effective range, although 2,000 yards is claimed for it. The axis of the barrels is thirty inches above the plane on which the piece stands. . . . Three infantry men, who were not thoroughly drilled, served each piece; these were fired rapidly, and apparently with good effect.

'Being breech-loading, and easily handled, scarcely any exposure above the parapet was required on the part of the gunners. . . . I feel quite satisfied that it is adapted to the defence of earthworks, particularly in a flat country, where the horizontal line of dispersion afforded by the fire of this piece is more effective than the cone of dispersion of the howitzer. It should be noted that the angle of dispersion can be varied to suit the case in this battery, which is not true of the howitzer. These properties, together with its small recoil and its loading at the breech, and lightness, are the qualities most desirable in a gun for boat service.' (*Engineer and Artillery Operations against Charleston*, Gillmore, New York, 1865.)

Request, Letters of. In Ecclesiastical Law, an instrument by which the regular judge of a cause waives or remits his own jurisdiction, under the provisions of the Statute of Citations, 23 Hen. VIII. c. 9; in which event the jurisdiction of the appellate court attaches.

Requests, Court of. 1. An ancient court of equity, inferior to the Court of Chancery, of which the lord privy seal was chief judge; taken away by 16 & 17 Ch. I. c. 10. 2. Local courts, termed courts of conscience or of requests, for the recovery of small demands, formerly existed in many parts of the country, having been established under special local Acts of Parliament (the first of which was stat. 1 Jas. I. c. 15), with a jurisdiction limited in each case to some particular district. In 1847 the general system of county courts was established, and the local courts of requests have been absorbed for the most part in this new jurisdiction. [COUNTY COURTS.]

Requiem. In the Roman Catholic Church, a mass performed for the repose of the souls of deceased persons. It is so called from the prayer commencing 'Requiem æternam dona eis, Domine.' The term is also applied to grand musical compositions performed on solemn occasions in honour of deceased civil or ecclesiastical dignitaries. The requiems composed by Mozart, Jomelli, and Cherubini are well known.

Reredos (Fr. arrière-dos, from Lat. dorsum, *the back*). In Ecclesiastical Architecture, a screen behind an altar. These screens in Winchester and Durham cathedrals, and in St. Albans abbey, are of great magnificence, and so large as to interfere with the general view of the choir. In conventual churches the reredos was the universal termination of the ritual presbytery.

Reree. An Indian name for *Typha angustifolia*, the leaves of which are used in the north-western provinces for making mats.

Resch Glutha. The Jewish title for the officer commonly known as the Prince of the Captivity. (Milman, *History of the Jews*, book xix.)

Rescripts (Lat. rescriptus, part. of rescribo, *I write back*). In the Civil Law, answers of popes and emperors to questions in jurisprudence propounded to them officially. Those of the Roman emperors constitute one of the authoritative sources of the civil law.

Rescue (Fr. recousse). In Law, in the more general sense, a species of resistance to lawful authority; as, by delivering one arrested out of the hands of those who have legal custody of him. In a more restricted application, the term *rescue* means the taking away and setting at liberty, against law, any distress taken for rent, or services, or damage feasant.

Resedaceæ (Reseda, one of the genera). A small natural order of Hypogynous Exogens, belonging to the Cistal alliance, and distinguished by not having tetramerous flowers, by their definite and not tetradynamous stamens, by their fruits being usually open at the point, and by their exalbuminous seeds. To this order belong the fragrant Mignonette of our gardens, *Reseda odorata*, and the dye plant called Weld, which is *Reseda Luteola*.

Reserve (Lat. reservo, *I keep back*). In Banking and Finance, that portion of his capital which a dealer in money retains in order to meet his average liabilities, and which he therefore does not employ in discounts or temporary loans. Long experience enables bankers to anticipate not only the amount of advances which they will be called on to make to their customers, but the average amount of claims which will be made upon them by their creditors when no disturbing cause, of which indeed they are sure to get early notice, has arisen. The amount retained for these recurring emergencies is, we are told, generally one-third of the bank's liabilities, when (as is the case with all prudent banking) advances are made only at short dates. Of course when an exceptional state of things occurs, the banker strengthens his reserve as far as he possibly can, by declining accommodation in some cases and by limiting the amount of his loans in all others. The natural machinery for these precautions is a rise in the rate of discount. When such emergencies arise, the customers of the bank, in order to fortify themselves against any pressure, accumulate their deposits; and consequently it is found, as a rule,

that the aggregate accounts of the customers who employ the bank as their commercial agent, and the reserve of the bank, rise and fall mutually. The necessity of a reserve is manifest. Whatever may be the assets of a bank, and however readily they may be disposed of, there is always great inconvenience and loss in negotiating the best securities in times of commercial difficulty.

Most of the specie in the country which is not needed for its circulation is, when the advantages of a sound banking system are understood by the public, left in the hands of bankers. The risks attending the habit of private hoarding are far larger than those which may arise from committing accumulations of specie and notes to a trustworthy bank; and in the case of such traders as need accommodation from banks, a private hoard would be a source of weakness rather than of strength. Hence the surplus coin and notes of this country are found in these institutions, and it is from these that extraordinary payments on foreign accounts have to be made. But while the general use of banking has general and manifest advantages, it cannot be doubted that, under the existing law which regulates issues, it renders these fluctuations in the rate of discount more considerable and more onerous, since they are mainly, if not altogether, relative to the amount of the reserve possessed by the Bank of England. The best remedy that could be devised against some of the fluctuations in the rate of discount would be found, it is believed, in the adoption of an international note currency, by which it might be possible that notes should be payable all over the civilised world at fixed rates of exchange. It does not seem that there are many more difficulties in such a system than there are in establishing a uniform currency in any single community. The reserve of the Bank of England is generally called *rest*, while the term *reserve* is employed to denote the amount of gold and notes held by the Bank, on which the demands for discount operate, and which by its increase or diminution affects the rate of discount.

Reserve. In Military language, a body of troops kept back in action, to give support when needed, or to be rallied on, in case of disaster.

Reserve. In Theology, the system according to which only that portion of the truth is set before the people, which they are regarded as able to comprehend or to receive with benefit. It is also known among Roman Catholic writers as the Economy. (Newman's *Apologia pro Vitâ suâ.*) [Discipline of the Secret.]

Reservoir (Fr.). A tank or pond in which water is collected and preserved in order to be conveyed through pipes for the supply of a town or canal, or for any other purpose.

It is often necessary to establish a means of regulating the discharge of the superficial watercourses of a district, either because the configuration of the ground presents too rapid a declivity, or is not of a nature to store the winter's rain, so as to give it forth again in the summer; or because the length of the valleys is not sufficient to allow of the collection of a sufficient number of rills, or subsidiary watercourses, to constitute a large river. All these conditions occur in the north of England especially, where reservoirs are indispensable for the supply of canals and mill-dams, and to meet the wants of the great towns. In tropical countries reservoirs are chiefly required for storing water for purposes of irrigation, and in some cases they are employed to retain sufficient water to equalise the flow of rivers, so as to render them more navigable in dry seasons.

In constructing a reservoir, it is advisable to select the greatest slope that can be commanded in order to collect the largest possible quantity of rainfall in the reservoir, which should be established in the narrowest part of the gorge that the stream has formed for itself, and with a valley widening out behind; provided always that this gorge be situated in a position not exposed to the danger of communicating with the lines of underground waters, or springs, and that the bottom is not of a nature to allow the rapid absorption of the water. It is scarcely necessary to remark that water for distribution in towns must be far purer than that which is needed for the supply of a canal; but generally it may be considered that the waters collected from the primitive formations are tolerably free from the impurities commonly met with in the lower secondary formations, in the sandstones, clays, marls, and the gravels and clays of the tertiary and quaternary formations. As the nature of the soil of a valley has a great influence upon the manner in which the water is retained, great attention must be paid to its permeability and hygroscopic character. The considerations relating to this branch of the subject are connected with the chemistry of water, and they are very obscure. In the regions formed of the primary series, or of the earlier secondary series, the rocks met with are slightly permeable, to a certain depth; but they are not hygroscopic, i.e. they do not take in, and hold up the water, to give it out again when the surface of the stone is laid bare. It is in the more recent formations that the hygroscopic character is most apparent, and in these therefore the establishment of storm or flood water reservoirs is more objectionable, while there is the further danger of the rock being fissured, and thus giving rise to the occurrence of springs and underground currents of water, which so seriously affect the stability of the enclosure dams. As a general rule it is found to be better, and safer, to establish these in valleys filled in with clays derived from the decomposition of the primary formations, which are very slightly permeable. Underground communications with the strata in the lower part may possibly account for the slipping of the bank of the Dale Dyke reservoir; and, therefore, too much care cannot be taken in ascer-

taining beforehand all the characters of the strata, before exposing them to the great head of water which must be brought to bear upon them. In the north of England and in Scotland, such clays occur in great abundance; but where they are wanting, the great increase of expense renders the formation of a reservoir almost impracticable. The best strata for reservoirs are the granite, porphyries, gneiss, and quartz rock, provided that their surfaces are not covered with the detritus washed down from their eminences, or broken up by subsequent movements of the soil. The slate rocks are generally too much intersected with veins of greenstone and trap-rock to be adapted for the purpose. The old red sandstones are objectionable, as being highly absorbent, and thus giving rise to the formation of land springs; the suitableness of the carboniferous sandstones varies much on account of movements of the soil subsequent to their deposition; but if the sandstones should be covered with the clays common in this set of formations, there are few better fitted for the purpose under consideration. The new red sandstones may generally be resorted to without fear of the rupture of the bank, although its great permeability renders the rock unsatisfactory. The primary limestones are objectionable on the same grounds, but they are often resorted to, as are the lias and the oolitic formations in the parts covered with clays and marls. The subcretaceous and the cretaceous formations are generally so permeable as to be almost useless, while the tertiary formations are only partially adapted for the purpose of reservoirs, the Brent reservoir being, indeed, the only one of any size formed in the clays of the London basin. The quaternary rocks are of very variable nature, but they are not generally fitted for reservoir making, as being too permeable and depending upon the substrata to uphold the water collected in them.

In the granite, and the other primary or secondary non-absorbent rocks, it is generally better to construct the dams of masonry; but whenever it can be done with economy, there can be no reason to adopt any other course than that of forming these dams in earthwork. In most of the French embankments for the supply of the canals, the reservoirs are closed by walls, and the irrigation reservoirs of Spain are mostly of the same description; in England, however, we have few reservoirs which are not formed with earthen dams, walls being seldom used for the purpose. The construction of such walls gives rise to dangers which must be carefully guarded against; but when the requisite precautions have been taken, there seem to be many reasons for preferring walls to earthwork, as they can be built more upright (and therefore with less surface exposed to the water), while, from not occupying so large a space as the earthwork, dams may be raised at a less expense of room. These masonry dams admit, further, of the establishment of works required to clear the bottom from the accumulation of débris and alluvial matter. The reservoirs of Alicante, Lorca, Almansa, &c., may be cited as illustrations of the necessity of constructing walls for such purposes.

The preliminary soundings of the valleys are of the greatest importance, and too great care cannot be paid to the indications thus afforded. The dam of the Estrecho de Rientes may be adduced as an example. In this case, the valley situated a little above the town of Lorca was barred by a dam destined to hold up the water to the height of 167 feet, and this enormous quantity of water was actually retained in the reservoir at the time of its bursting. The catastrophe was caused by the water finding its way through the sand and gravel at the bottom of the valley, which had been carelessly and hastily sounded. The consequence was that the wall was broken, and a large tunnel, about 100 feet high and 70 feet broad, was formed in the deepest part of the enclosure, through which the contents of the reservoir were emptied in the space of an hour. According to the official accounts, as many as 608 persons were drowned, amongst whom was Don Antonio Robles, the director of the works, while 809 houses were destroyed, and the damage done to real property, and to beasts and crops, was estimated at 140,000*l*., an enormous sum if we take into account the period and the value of money in Spain. This reservoir had been in use for eleven years, and might have resisted indefinitely if the height of the water had been confined to about 70 feet. On April 30, 1802, however, the waters rose to the height of 156 feet, and the wall was swept away; the bottom of the gallery by which the water was let off being the first to yield under the enormous pressure to which it was exposed without a counterbalancing weight on the inside. The lesson to be drawn from this accident is that a piled foundation can never be trusted to resist the upward pressure of a great head of water.

It is of the highest importance that the masonry of the reservoir walls should be rendered perfectly water-tight, a condition which can only be secured by the employment of hydraulic lime. It may, indeed, happen that the materials used for the masonry may be of a nature to act chemically upon the lime, as in the case of granite, which has a notable proportion of soluble felspar in its composition; but such conditions can be regarded only as happy accidents, and should never be counted upon. In the Spanish irrigation reservoirs, the walls are made with a vertical face to the water, and are executed of large ashlars. At the Rientes de Lorca, the thickness of the crown was made about 36 feet, and the slope of the surface away from the water was made at the inclination of 2 in height to 1 of base, with 4 large sets-off of 11 feet each in width. The Spaniards generally execute these reservoirs of a circular or polygonal form in plan, with the apex pointing up the stream, the resistance of the mountain being thus brought to aid that of the masonry against the pressure

of the water. The circles are struck with a radius of about 350 feet in the case of the reservoir of Alicante, one of the boldest and most successful pieces of engineering ever executed. The thickness of the wall is made, at the top, about 67 feet, the masonry batters towards the upper part of the stream 10 feet; the thickness at the bottom is 112 feet; and the difference between the top and bottom of the wall is gradually distributed throughout the height, aided by 7 sets-off that vary between 3 feet 4 inches and 1 foot 8 inches in width. It is executed in a hard primary limestone rock, and the overflow is made in two streams, each of them 6 feet wide and 7 feet below the crown of the dam, which has an inclination from the surface of the reservoir of 3 feet 4 inches. This extraordinary depth of overflow does not appear to have been too much, as the crown of the dam has been very frequently washed over in the storms which ravage the mountains where the reservoir is situated. Indeed, on September 8, 1792, the waters rose to the height of 8 feet 3 inches above the dam, and poured over it in a magnificent cascade; and the perfect manner in which the wall supported this extraordinary test has induced the inhabitants of the valley to trust entirely to the wall, and they have actually closed the overflow. The total quantity of water capable of being stored in the reservoir of Alicante is calculated at 131 millions of cubic feet. It is said that Herrera, the architect of the Escurial, was the author of this magnificent project, which was executed between the years 1579 and 1594. The height of the water, it may be remarked, is in this case, not less than 134 feet 6 inches, or greatly in excess of the depth of the Dale Dyke reservoir.

Whatever difficulties the Spanish engineers may have encountered, from the rarity of hydraulic lime in that country, there is no instance of the occurrence of a dam in earthwork upon the irrigation canals, or the derivations of rivers, executed for the supply of water to the population of towns. On the French canals, however, earthen dams are as common as the masonry walls of Spain. In England, the preference seems to have been, in all cases, accorded to the earthen dams, which are also largely employed in Italy. In India, the country where irrigation has for ages been practised on the largest scale, the earthen dams have long engaged the engineer's attention, and the failure of the dams is very rare. The surface of the country in most districts is studded with reservoirs, or tanks, as they are called, to retain the surplus rains of the monsoon; for where water is the only condition of fertility, every pint of water is valuable, as it in fact represents so much corn or other produce. Some of the Indian and Cingalese tanks are, in fact, artificial lakes, a few being as much as eight miles long; and many of these works have descended in unimpaired efficiency from a remote age. These reservoirs are almost invariably formed with dams of earthwork built across a valley. The practice of every country in the execution of such works has been, in fact, regulated partly by the local conditions with which they had to deal, and partly by considerations of economy. But besides these motives it is necessary to take into account the habits of the workmen. In England, for instance, the workmen have acquired, from long habit, a great skill in the preparation of puddle; in India, the native workmen consolidate the banks in a superior manner by their mode of carrying on the earthwork; whilst in France the execution of the walls can always be intrusted to the care of the men, who are accustomed to the use of hydraulic lime. Of late years, however, the shortness of the time now allowed for the execution of large banks in England, has somewhat modified the preference there given to the ancient style of dam-making.

The earthwork of the dams ought to be, as far as possible, executed of such materials as would exclude the water from traversing the body of the dam: it ought theoretically to be formed of a mixture of clay and gravel, which should both resist the infiltration of the water, and at the same time the boring of rats and moles. Earth so composed is seldom found, and engineers are commonly obliged to have recourse to a *puddle trench*, carried down to the foundation of the bank, and continued to about 3 feet from the top. On the resistance offered by this puddle lining (which must be regarded as a wall in the body of the bank), the success of the reservoir must depend, and there appears to be little reason for not making the thickness of the puddle trench on the average at least one-third of the height of the bank. The latter is usually made in England with an internal slope of 1 in height to 3 in base, though the French engineers have usually adopted a much steeper slope. The top of the bank is habitually made about 20 feet wide, the external slope being made at the inclination of 2 in base to 1 in height. But in all cases where these proportions have been observed, great care has been taken that the materials of which the bank is composed shall be made as homogeneous and as water-tight as possible; and the French engineers, and Mr. Leslie of the Edinburgh water-works, even prescribe that the earthworks of which the banks are formed shall be carried up in layers of not more than 4 or 6 inches in thickness, and that they shall be carefully rammed to insure their equal settlement. The French engineers take the additional precaution of watering the surface of the ground with lime water, and prescribe that the thickness of the layers shall be about 9 inches, reduced by ramming to 6 inches; but in this case they dispense with the internal puddle wall. In all cases, however, the French engineers attach great importance to the execution of the pierré, or stone pitching, which they form in separate and independent walls, so that one part shall not entail the ruin of all the rest. This system has

been applied on a large scale in the reservoirs of Torcy and Berthand on the Canal du Centre, and recently in the reservoir Montaubry.

The materials of which the banks are made must determine the profile to be given to the dam. In the Haslingden reservoir, recently completed, but not yet at work, the materials obtained in the neighbourhood were found to be composed of clay, with layers of shale, and a great deal of sand interspersed; and hence it became necessary so to increase the slope of the banks, in order to enable the earth of which they were composed to assume a permanent inclination, that at length it attained as much as 1 in 6 on the average. The same thing occurred in the Halifax water-works, where the materials employed are for the most part of a peaty nature; but in such cases the system of executing the pitching in walls susceptible of independent movements ceases to apply. In fact, the great use of the pitching is to keep up the bank when the water sinks lower in the reservoir, or is withdrawn for the purpose of examining and repairing. It would be, perhaps, more advisable to execute the pitching in independent walls if the earth be of a firm nature; but it is better to trust to the weight of the pitching to keep down the foot of the bank if the latter should have any tendency to *spew*, as the workmen phrase it; and this is effected more economically by spreading the thickness of the pitching over the whole surface of the slope thrown out to a great angle.

No definite rule seems to determine the height of the overflow, but it seems by general consent to be left at 5 feet below the top line of the bank, although there are many cases in which this height is insufficient. At the reservoir of Torcy, the waves were known to have broken and been carried to the height of 20 feet; nor can this be considered extraordinary, as the reservoir in question was at least 60 feet deep, and the wind blew directly on the greatest length. It may, therefore, be taken as a general rule, that the overflow should be executed at 7 feet below the finished line of the earthwork of the dam as at first carried into effect; because this will, in the first place, certainly sink about 2 feet in the height of 60 feet, and there is no harm in executing a little more earthwork than is strictly necessary, provided that greater security be thereby attained. The width of the overflow ought to be such that, with a flow of two feet over the crown, it should be able to discharge all the water brought down by the severest floods ever known to fall upon the basin supplying the reservoir; and this, without reference to the power of diminishing the quantity of water by the intermediate sluices. When masonry walls are used for the purpose of closing the valleys, there is less occasion to pay much attention to the size, or even to the existence, of the overflow, as the water may in such cases flow over the top of the wall, without any fear of endangering it. The Alicante dam may be cited in proof of this assertion.

Much was said about the mode of execution adopted in the case of the Dale Dyke, with respect to the pipes for drawing off the water for the supply of the town; and though it would be undoubtedly better to carry these works upon the natural foundations of the valleys, yet the event proved that no evil was inflicted by the system of artificial foundations adopted. It is, however, notorious that the pipes were laid under disadvantageous conditions; and this part of the works would unquestionably have been far better executed, if there had been a tunnel laid through the bank, which might have served to carry off the flood waters during the erection of the bank itself, and to receive the pipes destined to empty the reservoir. In France and Spain, this plan is generally adopted; and in all the canal reservoirs of the former, and the irrigation reservoirs of the latter country, there are a series of draw-off tunnels, designed to relieve the bank from the weight of water, and to draw off the supply at different levels; these tunnels being generally three in number, and placed, one alternately on each side, and the third, at the bottom level, in the very axis of the natural watercourse. If these tunnels can be executed in the firm strata of the valleys, it is of course desirable to do so; but there is no necessity for so doing, if the water can be prevented from passing along the top of the masonry or under the foundations of the tunnels, or if precautions are taken to insure that the masonry of the tunnels shall not suffer from unequal settlements of the wall or bank in which it is executed. At the barrage of Alicante the water is drawn off by a well, which occupies the inner thickness of the masonry from top to bottom, and both the gallery that leads the water to the distributing channels, and the scouring sluice, are constructed without reference to the natural surface of the ground. The height of this reservoir, at the point where the scouring sluice is placed, is 136 feet at least; so that it would appear that the position of the tunnels for the outlet of the waters depends entirely upon the manner in which they are executed, rather than upon the precise position which they may occupy. It may be added that the system adopted in the well pits and culverts of the Bradford reservoirs closely resembles that of the Spanish engineers. In this case the puddle wall was formed of less than the thickness which we have mentioned as advisable, probably because the materials of which the embankments themselves were composed were such as to allow of their being more closely packed. At any rate, the inner slope of these banks was made 3 to 1, and the outer slope $2\frac{1}{2}$ to 1; the thickness of the bank at the top being 15 feet on the average, and the height of water retained in these reservoirs being as much as 72 feet above the bottom of the outlet.

The thickness of the retaining wall or em-

bankment may be calculated upon the following principles, if the communication of the water from the upper to the lower side of the reservoir by means of springs or subterranean water-courses be totally excluded. This condition is the 'be all and the end all' of the establishment of such collections of water, and too great precautions cannot be observed to insure the attainment of it. The ground must, of course, be carefully examined, and the effects of the increased head of water must be carefully allowed for. The bottom must be such as will not absorb water, and it must have an inclination which shall not allow the water to escape or to be lost by evaporation from the surface. In fact, everything depends upon the strict impermeability of the soil employed as the foundation of the banks of reservoirs; and if this condition be not obtained, the accidents at the Torcy, the Rientes, and the Dale Dyke reservoirs will inevitably be repeated. Indeed, the dangers to which the banks or walls are exposed, can at times be so much increased by the yielding nature of their foundations, that the importance of ascertaining the nature of the latter cannot be exaggerated. Thus the foundations of the reservoir of Grosbois are upon an elastic clay; and though the thickness of the wall is calculated to resist a greater weight of water than is contained in the reservoir, yet the movement of the soil under its weight and that of the wall gives rise to corresponding movements in the masonry, which do not take place with the reservoir of Sétous, founded on the solid granite, or the reservoir of Alicante, which rests on a hard limestone.

The resistance of the bank or wall of a reservoir may be considered under three different conditions: (1) under the condition of the resistance which it may present to the forces tending to overthrow it, by causing it to turn upon the outer edge; (2) under the condition of the weight supported by the soil of the foundations, and the materials of which it is composed, which would tend to crush them; and (3) under the condition of its offering a sufficient resistance to a force that would tend to produce an effect of sliding or of friction upon the base or upon the lower courses of the masonry. In calculating the dimensions of the reservoirs, it is usual to leave out of account the weight of the parapets and of all incidental works and to consider the water as acting upon the total height of the resisting surface of the wall, without taking into account the resistance offered by the ground thrown out for the foundations. This is, perhaps, counting upon too great an effort, in many circumstances at least; but the consequences of the overthrow of a dam are so fearful, that there are no reasons why the rule should be altered to suit the few exceptional cases. In the north of England, however, it would seem that of late years care has seldom been taken to calculate the resistance of the banks, and this fact may possibly account for the failures that have cast such discredit on our engineering.

In earthen dams, it is seldom necessary to ascertain the resistance either to the effort to turn the embankment over on the outer edge, or to the effort of crushing the foundations; but the tendency of the weight to produce the movement of the bank upon the bed, and the danger that may arise from the slipping of the materials of which it is composed, must be seriously considered. It is only with reference to the resistance of walls of masonry that the considerations first mentioned begin to be of importance, for the pressure supported by a bank of earth is always less than the resistance which this bank would offer if proper care be taken in the composition of it. Thus, it has been shown by Navier (*Résumé des Leçons données à l'École des Ponts et Chaussées*) that the pressure supported by a vertical section (of infinitely small dimensions) of the height of the bank would be, on the supposition that the angle of the bank were 45°, $Q = \frac{\varpi b^2}{2}$; in which ϖ is made equal to the specific gravity of the water, while b represents the height of the water above the position considered, or, in other words, the pressure is equal to the area of the slope multiplied by the square of the height of the water divided by two. If we construct the rectangle representing the force, and apply it to the point where it would act upon the bank, i.e. at a point situated at one-third of the height from the bottom, and at the same time observing that the resultant of this pressure is normal to the line of the bank, we should see that the pressure would have a tendency to drive the bank into the earth. Decomposing this force into two other forces, of which one, n, is destroyed by the resistance of the ground to which it is perpendicular, while m represents the tendency of the bank to slip upon its base in a parallel direction to the horizon, we may thus estimate this force in a function of h. We have, in the first place, $Q = \frac{\varpi b^2}{2}$ and $2m^2 = Q^2$ for $m = n$. From this we may derive the formulæ $m^2 = \frac{\varpi^2 b^4}{4} \times \frac{1}{2}$, and $m = \frac{\varpi b^2}{2}\sqrt{\frac{1}{2}} = \varpi b^2 \times \sqrt{\frac{1}{8}}$, so that the horizontal pressure supported by the bank is equal to the square of the height of the water multiplied by the weight of unity thereof, multiplied by the square root of $\frac{1}{8}$. If, now, we suppose that the earth of which the bank is composed has the same specific gravity as the water, and at the same time that this is the only resistance to be overcome by the pressure of the water, we shall find that the resistance R, opposed to the force Q, is greater than this is; for, in fact, we have $R = fb \times \frac{1}{2}b \times \varpi$, and replacing fb by its value b,

$$R = 2b \times \tfrac{1}{2} b\varpi = b^2\varpi;$$

from which it would appear, that even upon the most unfavourable supposition the power that tends to press the bank in such a manner as to cause it to slide upon its base, is only a little more than one-third of the resistance this

would offer to it. We must, then, seek elsewhere the causes of the recent failures of reservoir banks. These causes cannot be traced to a deficiency in the quantity of materials employed; and depending as they do on the conditions of the soil and the foundations, they can hardly be the subject of strict mathematical reasoning. It is all-important, however, that the passage of the water from the upper to the lower side be prevented, not only because by this means the gravity of the bank is decreased, but also because there is a danger of the lateral displacement of the earth by the increased tendency to slip upon the bed that would be produced by the water mingling with the materials. Under these circumstances, it cannot be too often repeated that the foundations of the bank must be carried down to such a depth as shall effectually exclude any kind of communication between the strata on the two sides of it; that the bank be composed of materials capable of resisting, as far as possible, the transmission of water, and of maintaining themselves at a reasonable slope even when filled with moisture, and that the height of the crown of the dam should be made sufficiently great above the waste weir to resist the action of the waves.

The precautions to be observed with regard to the position of the by-washes, overfalls, and pipes for the supply of the water, must be regulated by the circumstances of the reservoir or by the purpose for which it is to be used. It would be dangerous to lay down any law with respect to the size, position, and details of these accessory works; and we need only remark that they must be of such dimensions and so placed as to enable the men charged with the superintendence of the reservoir always to exercise an efficient control over the water flowing into it, and never to allow the waters to become their masters. In the case of the Dale Dyke reservoir, for instance, the dimensions of the pipes laid through the bank were not large enough to carry off the whole of the flood waters brought down by the drainage of the upper lands, and the waters consequently accumulated to a height dangerous to the security of the reservoir. All this danger might have been avoided by draw-off pipes or overflows of larger dimensions, and by placing the overflows at a height which should leave the crown of the dam considerably above the flood-line. The laws which regulate the discharge of water in these cases are, of course, well known; the essential conditions of the stability of reservoir banks are connected with the foundations, and the structure of the dam itself.

Reset of Theft. In Scottish Law, the crime of receiving and retaining stolen goods knowing them to have been stolen. [RECEIVING.]

Residual Products of Gas Manufacture. The chief of these are coke, which remains in the retort after the gas has escaped, ammoniacal liquor, and tar, which separate from the gas during the passage of the latter through the condensers. Ammoniacal liquor consists chiefly of carbonate and sulphide of ammonium in aqueous solution; it is the principal source of ammoniacal salts, such as sulphate of ammonium, chloride of ammonium, &c. The tar is found as a separate heavy layer of thick oily liquid beneath the ammoniacal liquor. Its composition and uses are described under COAL TAR.

Residuary Legatee. In Law, one to whom a RESIDUE is bequeathed.

Residue (Lat. residuus, *that which remains*). In Law, the remainder of a testator's estate after payment of debts and legacies: if this remainder be bequeathed to anyone, he is styled the *residuary legatee*. If a legatee dies before the testator, the legacy is a lost or *lapsed* legacy, and sinks into the residue; and this provision of the law is extended to devises of real property by 7 Wm. IV. and 1 Vict. c. 26 (the Wills Act) s. 25. [LEGACY; WILL.]

RESIDUE. In the Theory of Numbers, the term *residue*, as applied to any given number n, and with reference to a certain modulus p, denotes any positive or negative number congruous with n for the modulus p. Thus either of the numbers 53 or -7 may be said to be a residue of the other for the modulus 5, for $53=12\times5-7$ that is $53\equiv-7$. The numbers $0, 1, 2, \ldots p-1$ are called the *minimum positive residues* for the modulus p, and any numbers respectively congruous to these are said to constitute a *complete system*. When p is a prime, any $\frac{p-1}{2}$ numbers are said to form a *half system of residues* for the modulus p; if taken positively as well as negatively, they constitute a system of residues prime to p.

The *residues of powers* of numbers, for a certain modulus, are termed respectively *quadratic, cubic, biquadratic, &c., residues*. Thus with respect to the modulus 5 the residues $9, -3, 1$ of 7^2, 3^3, 2^4 &c. would be termed, respectively, a *quadratic*, a *cubic*, and a *biquadratic* residue. The residues of powers play an important part in the theory of numbers: their properties were first investigated by Euler. (*Comment. Arith. Coll. Petropoli*, 1849.)

Resin (Gr. ῥητίνη). A proximate principle common in the vegetable kingdom, the ultimate components of which are carbon, oxygen, and hydrogen. There are many varieties of resin. Their general characters are fusibility and inflammability; solubility in alcohol, insolubility in water. They are generally separable into two distinct portions by the action of cold and of hot alcohol. They are valuable as ingredients in varnishes, and several of them are used in medicine. They are often naturally blended with modifications of gum, in which case they constitute the series of *gum resins*. The specific gravity of the resins varies between 1·0 and 1·4. They become negatively electric by friction. The commonest resin in use, usually called *rosin*, is obtained by distilling turpentine: the volatile oil passes over, and the resin remains in the still.

Among the resins are included: Copal, the product of *Rhus copallina*; Mastich, that of *Pistacia Lentiscus*; Coumia, that of *Icica Tacamahaca*; Carana, that of *Bursera acuminata*; and Elemi, that of *Amyris Plumieri*.

Resinite. [RETINITE.]

Resistance (Lat. resisto, *I withstand*). In Mechanics, this term denotes generally a force acting in opposition to another force, so as to destroy it or diminish its effect. Resistance is sometimes considered as of two kinds, active and passive; the active resistance being that which corresponds to the useful effect produced by a machine, and the passive that which belongs to the inertia of the machine. Thus, in raising water from a well, the active resistance to the force employed is measured by the quantity of water which is raised; and the passive resistance by the force required to overcome the weight of the bucket and the rope, the friction of the pulley on its axle, &c.

Resistance of Fluids. The force with which a solid body moving through a fluid is resisted or retarded. For many years the resistance experienced by a solid moving through a fluid, such as a ship sailing in the sea, was thought to be determinable only by certain recondite principles of hydrodynamics which theory could hardly reach; but it has of late been conclusively shown, that nearly nine-tenths of the resistance of well-formed ships is made up of friction. This doctrine, first propounded by Mr. Bourne in his *Treatise on the Screw Propeller*, and subsequently in his *Catechism of the Steam Engine*, published in 1856, has been further illustrated by Mr. Phipps, in a paper read before the Institution of Civil Engineers in 1865, and has been reduced to definite rules, of easy application, by Professor Rankine, in his *Treatise on Shipbuilding*, in course of publication in 1866. The subject was first pressed on Mr. Bourne's attention from having constructed ships on lines formed by allowing a pendulum, armed with a pencil, to vibrate in front of an endless web of paper, moving with a defined speed; since, as no power is lost by a pendulum beyond that which is lost by friction, Mr. Bourne concluded that a vessel formed on the principle that each particle of water shall be moved aside like a pendulum, slowly at first, and then faster, and by a reverse process shall finally come to rest at the stern, would be exempt from that large source of loss from the displacement of the water, which was then imputed to the progress of vessels of the ordinary character. It was found, however, on subjecting this hypothesis to the test of experiment, that although in the new class of vessels there was no wave raised at the bow, and no appearance anywhere of much resistance, the speed attained was little if at all superior to that of ordinary well-formed ships; and as in the new class of vessel the resistance was certainly, for the most part, produced by friction, the conclusion was reached that friction is the main cause of resistance in all vessels of moderately good form. Mr. Bourne accordingly proposed to estimate the resistance, not by the immersed midship section, as is the common method, but by the immersed perimeter, which would be an approximate measure of the resistance of all vessels of the same fineness and length. Nevertheless, as there was still a certain residuum of resistance depending upon the degree of sharpness of the vessel, or the difference in level between the bow and stern, Professor Rankine translated this resistance into surface friction also, by assuming as the rubbing surface of the vessel not the actual surface of the bottom but an *augmented* surface, which should be in all cases larger than the real surface, but larger in the proportion of the bluntness of the vessel, a common proportion of the augmented surface being 1·4 times that of the actual surface. In estimating the resistance of this augmented surface, the expression $f = \cdot 0036$, deduced by Professor Weisbach from experiments on the flow of water in iron pipes, was adopted as the coefficient of friction proper for the painted bottoms of iron vessels. The experiments, however, of M. Darcy, recently made in France, show that the friction of bare iron is one-half greater than if it is covered with a coat of smooth bitumen; and there can be no doubt that the condition of the surface of a ship's bottom will sensibly affect the speed attained. These topics are set forth at greater length than would be consistent with the limits of this article, in Mr. Bourne's *Hand-book of the Steam Engine*.

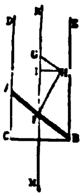
Sir Isaac Newton was the first who gave a general theory of the motions and actions of fluids; and it will be proper here to recapitulate the main doctrines of that theory, although, so far as regards its applicability to ships, it has now been superseded. [HYDRODYNAMICS.] The Newtonian theory of the resistance of fluids, which is given in the second book of the *Principia*, is founded on the assumption of the perfect intermobility of the particles of the fluid, and the equal propagation of pressure in all directions. These are, indeed, the characteristic properties of fluidity; nevertheless, the results of the mathematical theory differ so widely in many cases from actual experiment, that some philosophers have called into question the accuracy of the principles from which they are derived. The theory, however, notwithstanding its defects, furnishes some propositions of practical use. We shall, therefore, here give a general view of its leading principles.

It is evident that a solid body, in moving through a fluid, must communicate a motion to the fluid particles with which it successively comes in contact. Now, the quantity of motion communicated to the fluid is necessarily equal to that which is lost by the solid, and may therefore be taken as the measure of the resistance. From this it follows that the resistance upon a plane surface moved perpendicularly through a non-elastic fluid at rest, is proportional

to the density of the fluid, to the area of the plane, and to the square of the velocity.

On comparing this resistance with the force of gravity, we have the following theorem: *The direct resistance of an unelastic fluid on any plane surface is equal to the weight of a column of the fluid having the surface for its base, and for its altitude twice the height due to the velocity with which the surface moves through the fluid.*

The above measure of the force of resistance is deduced on the supposition that the direction of the motion is perpendicular to the plane. If the shock is received obliquely, the resistance will be greatly diminished.



Let AB represent the profile of the plane, and MN the direction of the motion of the plane in stagnant water, or of a vein of fluid DCBE striking against the plane, supposed to be fixed. Let F be the intersection of MN with AB, and draw BC perpendicular to MN. On FN take FG, to represent the resistance R, which AB would sustain if it were placed perpendicularly to MN, and were moving with the same velocity. This force FG may be resolved into two, FH perpendicular and HG parallel to AB, of which the latter produces no effect on the plane; hence the resistance is diminished, by reason of the oblique impact, in the ratio of FH : FG, or of sin i : 1 (i denoting the angle of incidence AFN). But, again, the absolute resistance is also proportional to the number of filaments which strike the plane; and it is obvious that the number which would strike it in the oblique position AB is less than the number which would strike it if directly opposed to the stream, in the ratio of BC : BA or of sin i : 1. Compounding this with the former ratio, the total diminution of resistance is as $\sin^2 i : 1$; i.e. the absolute resistance or pressure in the direction FH perpendicular to the plane is R $\sin^2 i$.

It still remains to find the effective impulse or resistance in the direction of the motion. Draw HI perpendicular to MM. The force in the direction FH may be resolved into FI and IH, of which the effective part is FI. Hence the effective impulse is to the absolute oblique impulse as FI to FH, or as sin i : 1; consequently the effective impulse on the plane in the direction MN is R $\sin^3 i$.

For other surfaces than planes, it is necessary to find an expression for the resistance on the differential element of the surface, which may be regarded as coinciding with its tangent plane; and the sum of all these resistances, found by the usual process of integration, will give the whole resistance on the surface.

Numerous experiments have been made for the purpose of ascertaining how far this theory of the resistance of fluids agrees with the actual facts, or for forming an empirical theory for the guidance of the engineer. Of the details of these experiments our limits will not permit us to give an account; but the principal experimenters, and works in which the results may be found, are the following: Sir Isaac Newton (*Principia*, lib. ii.); Mariotte (*Traité des Mouvemens des Eaux*); Gravesande (*System of Natural Philosophy*); D. Bernoulli and Krafft (*Comment. Petropol.*); Borda (*Mém. de l'Acad. des Sciences de Paris*, 1763 and 1767); Condorcet, D'Alembert, and Bossut, by order of the French government in 1775; Bossut (*Hydrodynamique*); Du Buat (*Principes d'Hydraulique*); Robins (*Gunnery*); Don George d'Ulloa (*Examen Maritimo*); Coulomb (*Mém. de l'Institut*, tom. iii.); Vince (*Phil. Trans.*); Hutton (*Tracts*); Beaufoy (*Nautical and Hydraulic Experiments*).

The quantity of fluid dragged along by a body moving in it has generally been considered to be independent of the velocity, and was estimated by Du Buat, from experiments made on spheres vibrating in water, to increase the quantity of displaced fluid in the ratio of 1 to 1·6. His experiments on prisms also showed that the quantity of dragged fluid was proportional to the bulk of the moving body. Mr. Baily (*Phil. Trans.* 1832) gives, as the mean results of his experiments on pendulums swinging in air, the ratio 1 to 1·846 as the increase of the displaced fluid from this cause; and remarks that the quantity appeared to depend on the form as well as magnitude of the moving body, but not on its weight or specific gravity. This circumstance, which considerably modifies the resistance, though made known by Du Buat in 1786, was overlooked by other experimenters, until rediscovered by Bessel in 1826, when engaged on experiments to determine the length of the seconds pendulum.

From the above considerations, it may be inferred that the resistance R opposed to any body moving through a fluid, considered as a pressure of so many pounds weight, will be expressed by an equation of this form,

$$R = (m + n)\,W A h;$$

where W is the weight in pounds of the unit of volume of the fluid (one cubic foot); A the area of the greatest transverse section of the body, expressed in square feet; h the height in feet due to the velocity, so that $h = v^2 \div 64$; and m and n numerical coefficients, constant for bodies of similar figure, but variable for bodies of different figures, and to be determined by experiment for each kind of body; m having reference to the impulse and pressure on the anterior surface, and n to the non-pressure on the posterior part. The following are a few of the cases for which values of m and n have been found.

When a thin plate is directly opposed to the impulse of a stream, the value of $m + n$ appears to increase with the area. If A is equal to a tenth of a square foot, $m + n = 1{\cdot}4$; and if A = 1 square foot, $m + n = 1{\cdot}9$. The value of $m + n$ for surfaces of larger dimensions has not been sufficiently determined. For a prismatic body terminated by two planes, the pressure

against the anterior force remains constant; but the non-pressure, or value of n, diminishes as the length increases. For a cube held fast in a stream, Du Buat found $m+n=1\cdot46$; and for a prism whose length was from three to six times the square root of its face, $m+n=1\cdot34$. But when the bodies moved in still water, he found, as for the thin plate, $m+n=1\cdot43$; for the cube, $m+n=1\cdot17$; and for the prism, $m+n=1\cdot10$.

By means of these values the actual resistances are readily computed for each body, when the velocity is given. Suppose the velocity to be 3 feet per second, and the opposing surface in each case to be 1 square foot. For $v=3$, we have $h=9+64=\cdot1406$. With respect to W, the weight of an imperial gallon of water, at temperature 62° and under the mean pressure, is 10 lbs. avoirdupois; but an imperial gallon contains 277·27 cubic inches, whence the weight of a cubic foot of water is 62·3 lbs. avoirdupois. Hence, if the bodies are impelled through stagnant water with a velocity of 3 feet per second, the absolute resistances in each case are as under:—

For the thin plate $R=1\cdot43\times62\cdot3\times\cdot1406=12\cdot5$ lbs.
For the cube $R=1\cdot17\times62\cdot3\times\cdot1406=10\cdot2$
For the prism $R=1\cdot10\times62\cdot3\times\cdot1406=\ 9\cdot6$

The effect produced by the addition of a poop or prow was also determined by Du Buat. The addition of a poop to a prismatic body whose length is four or five times its breadth only diminishes the resistance by a tenth part. But when a prow consisting of two equal vertical planes, making with each other an angle of 60°, was added, the resistance was reduced to about a half. On giving the prow the form of a semicylinder, the resistance was also reduced about a half. The section of the prow being a triangle whose height was double the base or breadth of the prism, the resistance was reduced to two-fifths. In general, a prow having a curved surface produces a greater diminution of the resistance than one of equal magnitude terminated by plane surfaces.

For a sphere moving in water or in air with a moderate velocity, the experiments give $m+n=0\cdot6$; but this value increases when the velocity becomes great, as in the case of a projectile. The experiments of Bossut on the model of a ship moved in the direction of its axis gave $m+n=0\cdot16$. This may be considered as the value corresponding to the solid of least resistance. For the effect with which solid bodies resist an effort tending to break or crush them, see STRENGTH OF MATERIALS; and for the resistance of the atmosphere on a projectile, see GUNNERY and PROJECTILE.

Resistance of Railway Trains. [RAILROADS.]

Resistance, Solid of Least. In Mechanics, the solid whose figure is such that in its motion through a fluid it sustains the least resistance of all others having the same length and base; or, on the other hand, being stationary in a current of fluid, offers the least interruption to the progress of that fluid. In the former case, it has been considered the best form for the stem of a ship; in the latter, the proper form for the pier of a bridge.

The law of resistance being known, the calculus enables us to determine the form of the solid of least resistance. Newton, in the thirty-fourth proposition of the second book of his *Principia*, has solved this problem on the hypothesis that the resistance is proportional to the square of the velocity.

Resistance of Steam Vessels. [STEAM NAVIGATION.]

Resolution (Lat. resolutio, from resolvo, *I unloose*). In Mathematics, this term is usually synonymous with *solution*. Thus the resolution of an equation is the procedure which leads ultimately to the discovery of its roots. [EQUATION.] The term is frequently used as the opposite of *composition*. Thus we speak of the resolution of a number into its prime factors, and of a force into its *components*. [COMPOSITION AND RESOLUTION OF FORCES.]

RESOLUTION. In Medicine and Surgery, this term implies the cessation or dispersion of inflammatory action without the formation of an abscess or mortification.

RESOLUTION. In Music, the writing out of a canon or fugue in partition from a single line.

RESOLUTION. In Parliamentary usage, 'every question, when agreed to, assumes the form either of an order or a resolution of the house. By its orders, the house directs its committees, its members, its officers, the order of its own proceedings, and the acts of all persons whom they may concern: by its resolutions, the house declares its own opinions and purposes.' (May, *Parliamentary Practice.*) [PARLIAMENT.]

Resolution of a Discord. In Music, the descent by a tone or a semitone, according as the mode may require, of a discord which has been heard in the preceding harmony.

Resolvent. In Algebra, an equation upon whose solution that of a given equation depends. [DIFFERENTIAL RESOLVENT.]

Resonance (Lat. resonantia, *a resounding*). In Music, a very indefinite term used in regard to the production or reverberation of sound.

Respiration (Lat. respiratio, from respiro, *I breathe*). The function by which the nutrient circulating fluid of an organised body is submitted to the influence of air, for the purpose of changing its properties. The great end which appears to be answered by respiration in animals is the removal of *carbonic acid* from venous blood. This gas is accordingly found in the air expired from the lungs; and the blood, having lost its carbonic acid, at the same time loses its dingy hue, and acquires the florid red which characterises arterial blood. The carbonic acid is attracted, as it were, out of the venous blood, by the oxygen of the air in the cellular structure of the lungs; while, at the same time, a portion of oxygen, about equal in bulk to that of the emitted carbonic acid, is absorbed by the blood, and contributes to its arterial character. The change from the arterial to the venous state, appears to take

place in the capillary junctions of the artery and vein; but how it is there effected we know not.

From the quantity of carbonic acid emitted from the lungs in a given time, it has been attempted to ascertain the quantity of carbon which is thrown off; but the usual estimates upon this subject, which place it at about 12 ounces in the 24 hours, are probably overrated, inasmuch as that quantity of carbon is more than that which exists in the food daily taken into the stomach. If we average it at 6 to 7 ounces, it will probably be nearer the truth. Besides carbonic acid, there is also a quantity of aqueous vapour thrown out with the expired air; this is probably produced chiefly by the superficial exhalants of the lungs, but it may also be partly derived from transpiration from the blood. It has not been satisfactorily ascertained whether the nitrogen of the air is affected by respiration. The most recent experiments would, however, seem to show that during fasting nitrogen is absorbed.

Respiration of Plants. [BOTANY.]

Respirator. An instrument fitted to cover the mouth, over which it is retained by proper bandages; it is constructed of a series of flattened silver or gilt wires, over and between which the air passes and repasses in the act of respiration and of speaking. It is presumed that the warm air emitted from the lungs imparts its excess of temperature to the small metallic bars, and that these in their turn impart heat to the cold air drawn through them at each inspiration; so that in this way the low temperature of the external air in cold weather is mitigated before it reaches the lungs, and its supposed noxious influence is prevented. When a handkerchief is tied over the mouth, and we are obliged to breathe through the nose, the extreme low temperature of the external air is similarly mitigated before it reaches the lungs.

Respite. In Law, a suspension, delay, or forbearance: as of the execution of a criminal sentence.

Respond (Lat. respondeo, *I answer*). A half pillar, or pier, introduced in a wall to support an arch; it constitutes, in fact, a continuation of the line of the arch in the horizontal part of the wall, and appears to be introduced for the purpose of supporting it.

Respondentia (Lat. respondeo, *I promise in return*). In Mercantile Law, a species of mortgage in the nature of bottomry, but differing from it in that the loan is effected on the security of the freight, and not on that of the ship itself. [BOTTOMRY.]

Responsible Government. In Politics, this term, although rather indefinite in point of phraseology, has acquired by usage a special meaning. All executive authorities, except the sovereign himself in a pure monarchy, are in truth *responsible* to some power or other for abuse of their functions; but under the British constitution, the ministry, together with its head, the prime minister, are in a peculiar sense *responsible* to parliament, i.e. it is the established usage that on a vote equivalent to *want of confidence* they should resign their offices, and make way for an administration more in harmony with the sentiments of the legislature. This system has been of late carried into practice in the larger British colonies, where the governor, appointed by the crown, is assisted by a ministry, appointed indeed by himself, but *responsible*, in the sense above indicated, to the colonial legislature. This system is, in common language, contrasted with that which prevails in other constitutional countries, and particularly the United States, where the president, elected for a term of four years, appoints a ministry dependent on himself, and not subject to change according to the votes of the legislature.

Rest (A.-Sax. ræst, Gr. rast). In Music, a pause or interval of time, during which there is an intermission of the voice or sound.

REST. [RESERVE.]

Restiaceæ (Restia, one of the genera). A natural order of Glumal Endogens, of little interest except to botanists. They occur chiefly in the woods and marshes of South America, New Holland, and Southern Africa, and are herbs or undershrubs, of a rush-like aspect.

Restiform (Lat. restis, *a rope*, and forma). In Anatomy, this term is applied to certain rope-like columns or tracts, behind the *lateral tracts* of the medulla oblongata. The *restiform tract* is continuous below with the posterior columns of the myelon; while above, its fibres may be traced transversely through the pons into the cerebellum. If the restiform tracts be irritated, the most acute suffering is produced.

Restitution of Conjugal Rights. In Law, the denomination of a suit between husband and wife, brought in the Court of Divorce and Matrimonial Causes, for the purpose of compelling cohabitation, if refused by either party.

Restitution, Writ of. In Law, a writ of restitution lies where judgment has been reversed, to restore to the defendant what he has lost by the effect of the erroneous judgment. Restitution of goods to a party robbed was unknown to the common law until the stat. 21 Hen. VIII. c. 11. By the statute 24 & 25 Vict. c. 96, it is now in the power of the court to award a writ of restitution of goods and chattels, or to restore them in a summary manner, where a thief or fraudulent taker has been indicted on the part of the owner and convicted. Such restitution cannot be granted of a valuable security, where the property has passed into other hands by a bonâ fide transaction. But a writ of restitution will reach goods stolen, although they have been sold in market overt. Restitution can be had only from the person in possession of the goods at the time of and after the felon's conviction.

Restoration, The. In English History, this name is applied by way of eminence to the restoration of Charles II. to the throne after an interregnum of eleven years and four months, from Jan. 30, 1649, when Charles I. was beheaded, till May 29, 1660.

Restriction of Cash Payments. Between February 27, 1797, and February 1, 1820, the Bank of England was permitted to issue notes for which the holder could not demand gold in exchange. This regulation is an important epoch in the history of banking. For the facts of the restriction and the resumption, see Tooke's *History of Prices*, especially vol. iv.

Resultant (Lat. resulto, *I rebound*). In Mechanics, the term *resultant* is applied to a *force*, *motion*, *velocity* or *rotation* which is mechanically equivalent to several other forces, motions, velocities or rotations. [COMPOSITION AND RESOLUTION OF FORCES AND ROTATIONS.]

In the *higher algebra*, the *resultant* of a system of homogeneous equations, involving as many variables as there are equations, is an important function of the coefficients which, equated to zero, expresses the condition of the existence of a common set of roots, and consequently the result of the elimination of all the variables. The synonymous term *eliminant*, now rarely used, was suggested by the latter property. The resultant is frequently considered apart from the system of equations, and is then referred to as the *resultant of a system of quantics*.

In the case of two binary quantics of the m^{th} and n^{th} degrees, respectively written thus,

$$\phi = a_0 x^m + a_1 x^{m-1} y + \ldots a_m y^m$$
$$= (a_0, a_1 \ldots a_m \between x, y)^m,$$
$$\psi = b_0 x^n + b_1 x^{n-1} y + \ldots b_n y^n$$
$$= (b_0, b_1 \ldots b_n \between x, y)^n$$

[QUANTICS], so that the coefficient in every term has a suffix equal to the exponent of the power of one of the facients y in that term, the resultant is a homogeneous function of the coefficients of each quantic of a degree equal to the order of the other quantic. In the above case, therefore, the resultant is of the n^{th} order in the coefficients a, and of the m^{th} in the coefficients b. Moreover, the sum of the suffixes in each term of the resultant is always constant, and equal to the product mn of the orders of the quantics. This constant sum is called the *weight* of the resultant. [WEIGHT OF A FUNCTION.] Thus the resultant of the two binary quadrics

$$(a_0, a_1, a_2 \between x, y)^2, (b_0, b_1, b_2 \between x, y)^2$$

is $(a_0 b_2 - a_2 b_0)^2 + (a_1 b_0 - a_0 b_1)(a_1 b_2 - a_2 b_1)$ which is of the 2nd order in each of the coefficients a and b, and whose weight is 4.

In general the resultant of any number of quantics of different orders is a homogeneous function of the coefficients of each, of a degree equal to the product of the orders of all the remaining quantics, and if the coefficients in the several quantics be affected with suffixes respectively equal to the exponents of the powers of some one of the facients which those coefficients multiply, the sum of the suffixes in every term of the resultant will be equal to the product of the orders of the quantics.

The well-known and important fact that a system of n homogeneous equations of the orders $m_1, m_2 \ldots m_n$, respectively, in $n+1$ variables can be satisfied, simultaneously, by $m_1 m_2 \ldots m_n$ systems of values of these variables, is an immediate consequence of the above properties of the resultant.

The resultant of a system of quantics can often be expressed as a determinant. [ELIMINATION.] For instance, the resultant of a system of n linear and homogeneous equations in n variables is the determinant of the n^{th} order whose constituents, in any column, are the several coefficients of one of the variables. Again, the resultant of the above two binary quadrics is the determinant

$$\begin{vmatrix} a_0, & a_1, & a_2, & 0 \\ 0, & a_0, & a_1, & a_2 \\ b_0, & b_1, & b_2, & 0 \\ 0, & b_0, & b_1, & b_2 \end{vmatrix}$$

When the given quantics are the several first derived functions of one and the same quantic, the resultant is called the *discriminant* of that quantic. [DISCRIMINANT.]

Resulting Trust. In Law, a species of trust arising by operation of law. If a purchaser of property takes a conveyance in the name of another person, then if there is nothing to indicate an intention of conferring a beneficial interest on such person, the trust or benefit of the property conveyed is said to result to the purchaser who paid for it. Again, if a settlement of property is made, and no trusts of it are declared, or if the trusts declared are not such as to exhaust the beneficial interest in the property, there is said to be a resulting trust to the settlor of the beneficial interest undisposed of.

Resulting Use. In Law, a species of use arising by operation of law. Where on a conveyance of the legal estate or seisin in lands no uses of it are declared, or if the uses declared are not sufficient to exhaust the whole fee simple, the use remaining undisposed of is said to result to the original owner. [RESULTING TRUST; USE.]

Resumption of Cash Payments. During the great continental war, and for four years after the battle of Waterloo, the Bank of England was empowered to issue inconvertible notes. For some portion of this time these notes were at a discount, the discount being greatest between 1810 and 1816. At the beginning of the year 1817, the directors of the Bank prepared to resume cash payments, but the negotiation of considerable loans on the part of France, Austria, and Russia, again affected the note circulation, and the natural process of resumption was checked for a time. It was resolved, however, that committees of both Houses of Parliament should report on the currency, and in consequence the Act of 1819, the first of Peel's Currency Acts, was passed. This Act provided that the Bank should exchange its notes for gold, such gold to be in ingots, and in quantities of not less than 60 ounces, first, from February 1 to October 1,

1820, at the rate of 4*l.* 1*s.* the oz.; next, from October 1, 1820, to May 1, 1821, at the rate of 3*l.* 19*s.* 6*d.*; lastly, between May 1, 1821, and May 1, 1823, at 3*l.* 17*s.* 10½*d.* After that date notes of all denominations and in all quantities were to be convertible on demand.

Resupinate (Lat. resupinatus, *lying on the back*). In Botany, a term applied to parts which become inverted, usually by the twisting of their stalk. It occurs in the case of many orchidaceous flowers, and the leaves of *Alströmeria*.

Resurrection. In Theology, this term is especially applied to the rising again of Christ from the dead, as narrated in the Gospels and the Acts of the Apostles.

Resuscitation (Lat. resuscitatio). This term is generally used to signify the restoring to animation of persons apparently dead. The first and principal object in these cases is to aërate the blood by the artificial introduction of fresh air into the lungs, and to restore the natural function of respiration. The lungs, therefore, must be inflated, and proper stimulants applied when necessary; among these, in cases of drowning and of apparent death from exposure to cold, friction is eminently important: after hanging, the vessels of the brain often require to be unloaded by venesection in the jugular vein. Galvanism is sometimes resorted to, but generally without effect. In all these cases no time should be lost, as everything depends upon *prompt* treatment, as well as upon *proper* means; and many lives have been lost for want of immediate aid, and skill in applying it. The attempts to restore suspended animation should not be given up till unequivocal proofs of death are manifest. The details of the management of different cases of apparent death are too extensive to come within our limits: upon this subject the reader may advantageously consult Taylor's *Medical Jurisprudence*. [DROWNING.]

Retainer (Lat. retineo, *I keep back*). In old English Law, a servant not dwelling in the master's house or employed by him in any distinct occupation, but wearing his *livery* (i.e. hat, badge, or suit), and attending on particular occasions: an important relic of the times of private warfare. The giving liveries, or *retaining* this class of servants, was forbidden by many statutes with little effect. The statutes themselves were repealed by 3 Ch. I. c. 1; but the usage had nearly ceased.

Retainer or **Retaining Fee.** In the language of the Bar, a fee given to a counsel to secure his services; or rather, as it has been said, to prevent the opposite side from engaging them. A *special* retainer is for a particular case expected to come on. A *general* retainer is given by a party desirous of securing a priority of claim on the counsel's services for any case which he may have in any court which that counsel attends. The effect of it is merely this, that if a counsel having a general retainer receive a special retainer on the other side, he cannot accept it until twenty-four hours after notice shall have been given of its arrival to the party so generally retaining him; when, if he does not receive a brief or a special retainer from the latter, he is bound to accept it. The same word in its strict legal acceptation signifies the engagement of an attorney by his client.

Retaining Wall. A wall built for the purpose of resisting the thrust of the ground at the back, or for confining a body of water in a reservoir. The principles to be observed in proportioning the thickness of these structures to their height, involve the most difficult problems with which the civil engineer has to deal. The foundations of retaining walls must be such that they shall not be liable to displacement laterally under the influence of the pressure behind them, nor vertically under the perpendicular weight brought upon them. According to circumstances, then, the foundations of a retaining wall may be carried down to the solid ground, they may be executed on piles, or they may be entirely of concrete. Local considerations of economy will, generally speaking, regulate the manner in which this part of a work will be executed; the only conditions which must be observed are that the sum of the forces tending to displace the wall shall be exceeded by the force tending to produce stability. The thickness to be given to the upper part of a retaining wall will very much depend on the nature of the material to be supported, and on the weight to be sustained; the thickness of such walls will have to be varied also in proportion to the length in which they may have to resist the weight brought upon them without any intermediate support. As a general rule, the thickness of retaining walls is made one-third of the height of the bank which they are intended to support, being diminished by sets-off on the inside, so as to preserve the perpendicularity of the external face; but the thickness of retaining walls destined to support the banks of rivers, or quays, is generally made about equal to one-half their height above the footings, on the average, in order to resist the action of the water upon the materials of the earthwork behind them. Of course, there are modifications of form, and dispositions of material in retaining walls, that may allow the thickness above given to be much reduced; as, for instance, the face of the walls may be made curvilinear in vertical section, or it may be made with counter forts, and circular parts like inverts, between: but the rules above given will generally apply, and the means adopted for saving masonry will demand superior execution or extraordinary care. For further details the reader is referred to Moseley's *Engineering and Architecture*; Murray, *On Retaining Walls*; Poncelet, *Sur les Revêtements*; Mayniel, *Sur la Poussée des Terres*; De Prony, *Nouvelle Architecture Hydraulique*; Navier, *Résumé des Leçons données à l'École des Ponts et Chaussées*; &c. But the indications given in all these cases must be received with a considerable amount of reserve, inasmuch as the earthwork at the back of the walls erected

to support them may become, when exposed to the tidal waters, loaded with a semi-fluid denser than water, which would greatly modify its action upon the walls. Hence the great thickness of the retaining walls of canals, reservoirs, sea walls, docks, &c. Much of the necessary thickness will depend upon the nature of the soil.

Retama (Arab. Ræetem). A genus of *Leguminosæ* closely allied to our Broom (*Sarothamnus*), and consisting of elegant shrubs, distributed over the Mediterranean region and the Canary Isles. Ræetem is the name given by the Arabs to a white-flowered species, *R. Rætam*, which grows in Arabia and Syria. According to Forskål, an infusion of its bitter roots is drunk by the Arabs for internal pains, and the shoots macerated in water are applied to wounds. The Arabic name Ræetem, altered slightly into *Retama*, is the common appellation of the plants of this genus in Spain. One of the species is of great utility in staying the sand along the shores of Spain, converting the most barren spots into odoriferous gardens. The young shoots are eagerly eaten by goats, and the twigs are used for tying bundles.

Retardation (Lat. retardatio, from tardus, *slow*). The act of hindering the free progress of a body, and ultimately, therefore, stopping it. It arises from the opposition of the medium *in* which the body moves, or from the friction of the surface *upon* which it moves. [FRICTION; RESISTANCE.]

RETARDATION. In Gunnery, the loss of velocity of a projectile, in consequence of the air's resistance. [GUNNERY.]

Rete Mucosum (Lat.). The soft matter, or layer, situated between the cuticle and the cutis; it is the seat of the colour of the skin. It is black in the negro, and the colouring matter is of such a nature as to admit of being bleached by the action of chlorine.

Retia Mirabilia (Lat. *wonderful nets*). The vaso-ganglionic structures, or network of blood-vessels, at the base and in other parts of the brain in vertebrata.

Retiaries (Lat. retiarius, from rete, *a net*). In Entomology, those spiders are so called which spin a web or net to entrap their prey.

Retiarii (Lat. from rete). The name of a class of Roman gladiators. The retiarius was furnished with a trident and net, with no more covering than a short tunic; and with these implements he endeavoured to entangle and despatch his adversary, who was called *secutor* (from sequi, *to follow*) and was armed with a helmet, a shield, and sword. [GLADIATORS.]

Reticulate (Lat. reticulatus, from rete). In Botany, formed like network. The term is especially employed to describe the condition of the venation in Exogens, as compared with that of Endogens.

RETICULATE. In Zoology, when a surface has a number of minute impressed lines which intersect each other in various directions, like the meshes of a net.

Reticulated Work. In Architecture, a method of executing masonry in which the stones are square and laid lozenge-wise, resembling the meshes of a net. This species of masonry is scarcely ever practised in the present day; but it was very common amongst the ancients.

Reticulates. The name of a section of Lithophytes, comprehending those in which the polype cells have a reticulate disposition on the surface of expanded plates.

Reticule (Lat. reticulum). In a telescope, a network of fine spider's webs or wires crossing each other at right angles, and dividing the field of view into a series of small equal squares. It has been long used for observations on the quantity of the enlightened parts of a luminary during eclipses; and is found well adapted for that and similar purposes.

Reticulum (Lat. dim. of rete). The name of the *honeycomb bag*, or second cavity of the complex stomach of the Ruminant quadrupeds; so called from the reticulate or honeycomb-like disposition of the cells, mostly hexagonal, which occupy its inner surface.

RETICULUM. In Botany, the débris of interlacing fibres found at the base of the petiole in palm-trees.

Retina. The pulpy expansion of the optic nerve in the interior of the eye; it is the seat of vision.

Retinaculum (Lat. *a hold-fast*). In Botany, the name of a hispid gland found on the stigmas of orchids and asclepiads, by which the pollen masses are held fast.

Retinalite (Gr. ῥητίνη, *resin*, and λίθος, *stone*). A massive variety of Serpentine with a resinous appearance, from Canada.

Retinite (Gr. ῥητίνη). A mineral substance, intermediate between resin and asphalt, discovered by Mr. Hatchett in roundish or irregular opaque lumps of a yellowish or pale brownish-yellow colour, in tertiary clay at Bovey Tracey, in Devonshire, associated with lignite; also at Halle, and in peat at Osnabrück in Hanover. When digested in alcohol, it yields a portion of resin, and asphalt remains.

Retinitis. Inflammation of the retina.

Retipeds (Lat. rete, and pes, *a foot*). The name given by Scopoli to one of the divisions of a binary arrangement of birds, including all those which have the skin of the tarsi divided into small polygonal scales.

Retired Flank. In Military art, a flank bent inwards towards the rear of the work or army, of which it forms a part.

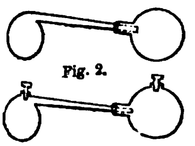
Retorsion (Lat. retorqueo, *I drive back*). In International Law, a designation for the use, by a power injured through the withdrawal by another power of the indulgences sanctioned by *comity of nations* in its favour, of the power of *retorting* by the withdrawal of the like indulgences from the latter. [COMITY.]

Retort (Lat. retortus, part. of retorqueo). A Chemical vessel employed in a variety of distillations. It is generally made of glass or earthenware, and sometimes is provided with a stopper so placed above the bulb as to enable

substances to be introduced into it without soiling the neck; in this case it is called a *tubulated* retort. A *receiver* is usually annexed to it for the purpose of collecting the products of distillation. Fig. 1 represents a plain retort and receiver; in fig. 2 both are tubulated. Retorts of large size, made of iron or of fire-clay, are used for the distillation of coal in the manufacture of gas.

Fig. 1.

Fig. 2.



Retreat (Fr. retraite). The name given to the beating of drums or sound of trumpets at sunset in all garrisons; after which sentries challenge, and no trumpet sounds or drum beats, except for watch-setting and tattoo, or in case of an alarm, until the following Reveille.

Retrenchment (Fr. retranchement). In Fortification, a line of works formed so as to cut off parts of a fortress, and enable the garrison to continue the defence after the parts outside of them are taken. [Fortification.]

Retrocedent (Lat. retrocedo, *I go back*). In Pathology, a term applied to those diseases which move about from one part of the body to another; as *retrocedent gout*, when it leaves the toe for the stomach.

Retrogradation. A term applied to the apparent motion of a planet when it is contrary to the order of the signs, or when the planet appears to move westward among the fixed stars. [Planet.]

Retrograde (Lat. retrogradis, *going backward*). This term is applied to backward as opposed to direct motion. In Astronomy, the apparent motion, from east to west, of the heavens is retrograde.

Retti Weights. The small egg-shaped scarlet and black seeds of *Abrus precatorius*, which are employed in India as weights.

Return. In Architecture, a projection, moulding, or wall continued in a different or an opposite direction to that of the original direction of the body returned.

Return. In Law, in its most usual signification, this word is applied to writs. The return to a writ is, properly speaking, a recital by the sheriff or other officer to whom it was directed of what he has done in execution of it, as, for example, in cases of civil process, that the defendant cannot be found (technically called *non est inventus*), has no goods within the sheriff's bailiwick (nulla bona), and so forth. This is indorsed on the writ; and the writ is then delivered into the court whence it issued on the *return day* or day when the writ is returnable. The remedy against the sheriff for a false return is by action on the case. The return of members of parliament is thus, strictly speaking, the return by the sheriff, or other returning officer, of the writ addressed to him, certifying the election in pursuance of it. [Parliament.]

Retuse (Lat. retusus, *blunted*). In Botany, a term applied to parts which terminate in a round end depressed in the centre.

Retzite. A red variety of Zeolite from Ædelfors in Sweden; named after Retzius, by whom it was analysed.

Reussin or **Reussite.** Anhydrous sulphate of soda and magnesia, occurring in crystals and in mealy efflorescences, near Seidlitz in Bohemia. Named after Reuss, the Austrian mineralogist.

Revalenta Arabica. The commercial name (formed by transposition from the name of the plant which yields it) for a much vaunted kind of meal, which is simply the prepared seeds of the Lentil, *Ervum Lens*. It is sometimes called Ervalenta, which comes nearer its true name.

Reveille (Fr. réveil, *an awaking*). The name given to the beating of drums or sound of trumpets at daybreak in all garrisons, after which sentries do not challenge till the following Retreat.

Revelation. [Theology.]

Revelation, Book of. [Apocalypse.]

Revels, Master of the, or **Lord of Misrule.** The name of an officer formerly attached pro tempore to royal and other distinguished houses, whose duty it was to preside over the Christmas entertainments. This office was first permanently instituted in the reign of Henry VIII.; it appears to have gone out of fashion towards the end of the seventeenth century.

Revendication (Fr.). A term of the Civil Law, signifying a claim legally made to recover property, by one claiming as owner. The right of property must, generally speaking, be complete, to proceed to the action of revendication; thus, no such action can be brought for corporeal things until after delivery, by which they pass.

Revenue (Fr. revenu). The name given to the income of a state derived from the customs, excise, taxation, and other sources, and appropriated to the payment of the national expenses. Useful and comprehensive tables, showing the revenue and expenditure of Great Britain, will be found in the parliamentary papers printed every session.

Reverberatory Furnace. A furnace in which the flame is made to pass over a bridge, and then beat down again upon a hearth or surface, on which the materials to be heated are placed. [Founding.]

Reverend (Lat. reverendus). A title of respect given to the clergy. In Roman Catholic countries the members of the different religious orders are styled *reverend*. In England deans are *very reverend*, bishops *right reverend*, and archbishops *most reverend*. In Scotland, the principals of the universities and the moderator of the General Assembly for the time being are styled *very reverend*.

Reverse (Lat. reversus, part. of reverto, *I turn back*). In Numismatics, the opposite to the obverse or face of the coin or medal. [Numismatics; Obverse.]

Reversed Dip. In mountain districts, as in the Alps, where the strata frequently show proof of having been lifted up by a force acting intensely, but with limited play, they have sometimes been lifted through an angle greater than a right angle. The result is that beds originally uppermost are now apparently underlying, and this phenomenon is expressed by the term *reversed dip.* Except in districts where there have been extensive movements, it is not likely that this condition of the beds can exist; but wherever it does occur, it is extremely puzzling to the young geologist.

Besides the cases in the Alps and other mountain tracts, there are not wanting folded strata, chiefly in the coal measures, where a reversion of dip is repeated over and over again. Such cases are common both in the French and Belgian coal-fields, and are the result of lateral pressure. Reversed dip has been noticed in some parts of England, though rarely. Beds thus displaced, if followed along their line of outcrop, are soon found to have their proper relative position.

Reversion. In Law, a reversion is defined to be the residue of an estate in lands, tenements, or hereditaments, left in the grantor, to commence in possession after the determination of some particular estate granted by him. Thus, for example, when a landlord grants a lease for years, the estate remaining in him is called the *reversion*, and carries the right to the rent reserved, although the tenant enjoys the actual posession of the land during his tenancy.

Reversion, Reversionary Payments. In the doctrine of Annuities, a reversion is a payment which is not to be received, or a benefit which does not begin, until the happening of some event, as the death of a person now living. Payments which are to be received at the end of a specified period of time are usually called *deferred payments.*

The present value of a sum of money to be received on the death of an individual of a given age depends evidently upon the chances which the individual has of surviving each future year of age, combined with the interest of money. The method by which the value is calculated, from an observed or assumed law of mortality, has been explained under the term ASSURANCE; and for the sake of facilitating calculations of this kind, which are of very frequent occurrence in the affairs of life, extensive tables have been published, computed from various hypotheses of mortality, and at different rates of interest. Such tables are usually exhibited in the form of Annuity Tables, from which the solution of all questions relating to assurance and reversions is easily deduced. [ANNUITY; ASSURANCE.]

Let A denote the value of an annuity of 1*l.* on a life of a given age, V the present value of 1*l.* to be received at the end of the year in which the life fails (the year being supposed to commence with the day on which the annuity is payable), r the rate of interest, and $v = 1 \div (1+r)$; then

$$V = v(1+A) - A, \text{ or } V = v - (1-v)A.$$

Suppose, for example, that on the death of *A.*, whose present age is fifty-five, the sum of 5,000*l.* is to revert to *B.*, or his assigns, and that *B.* proposes to sell his interest in this reversion; and let it be proposed to calculate the sum which he ought now to receive, allowing the purchaser interest at the rate of 4 per cent. per annum. In the table given under the term ANNUITY the value of an annuity of 1*l.* on a male life aged fifty-five is 11·0392. At 4 per cent. we have $r = \cdot 04$, and $v = 1 \div 1\cdot 04$; therefore $V = \frac{12\cdot 0392}{1\cdot 04} - 11\cdot 0392 = \cdot 5370$. This is the value of the reversion of 1*l.*; consequently 5,000*l.* × ·5370 = 2,685*l.* is the sum which *B.* should receive for his reversionary interest.

When the reversionary benefit consists of an annuity to commence upon the death of an individual, and to continue for a term of years certain, its value is found by computing the value of the annuity for the assigned period, and proceeding as in the above example; but when it consists of an annuity commencing upon the death of one individual, and terminable upon the death of another, it becomes necessary to have recourse to tables of annuities on joint lives. Thus, if *A.* becomes entitled upon the death of *B.* to an annuity of 1*l.* for the remainder of his life, the present value of the reversion, or of *A.*'s interest, is equal to B − A B; where B denotes the present value of the annuity on the life of *B.*, and A B the value of the annuity on the joint lives of *A.* and *B.*, that is to continue only so long as both remain alive.

The four following rules give the solution of all the cases of reversionary annuities which can arise when three lives are concerned, and it is seldom that a case occurs in practice involving a greater number. It is to be observed that the two letters A B standing together denote, as above, the value of an annuity on the joint lives of *A.* and *B.*, B P that of an annuity on the joint lives of *B.* and *P.*, A P Q that of an annuity on the joint continuance of the three lives *A.*, *P.*, *Q.*, and so on. Let R be the value of the reversionary annuity in each case.

1. On a single life *A.*, after the longest of two lives *P.* and *Q.*; R = A − A P − A Q + A P Q.
2. On the longest of two lives *A.*, *B.*, after a single life *P.*; R = A + B − A B − A P − B P + A P B.
3. On a single life *A.*, after two joint lives *P.*, *Q.*; R = A − A P Q.
4. On two joint lives *A.*, *B.*, after a single life *P.*; R = A B − A B P.

When reversionary benefits are contingent on lives failing in an assigned order, as for instance an annuity to be received upon the death of *A.* provided he die while *B.* is living, the formula becomes more intricate, and could scarcely be explained without entering into details inconsistent with the nature of this work. For full information on the subject, see the Treatises of Baily (1813) and Milne (1816). We may remark, however, that the formulæ for the so-

lutions of questions connected with this subject may be greatly simplified by the use of an appropriate notation: for examples of which, see the 'Essay on Probabilities' in the *Cabinet Cyclopædia*; and Hardy's *New and General Notation for Life Contingencies* (1840); in which last work the solutions of all the cases of annuities and assurances which can arise, when not more than three lives are concerned, are arranged in a convenient table.

Reversion of Series. In Algebra, a method of expressing the value of an unknown quantity which is involved in an infinite series of terms, by means of another series of terms, involving the powers of the quantity to which the proposed series is equal. Thus if the proposed series be

$$z = ax + bx^2 + cx^3 + dx^4 + \ldots \text{ad inf.} \ldots (1)$$

and if we assume

$$x = Az + Bz^2 + Cz^3 + Dz^4 + \ldots \text{ad inf.} \ldots (2)$$

the original series will be reverted on determining the coefficients A, B, C, D, &c.

The ordinary method consists in substituting the last series (2) and its powers for x and its powers in the series (1), and equating the coefficients of like powers of z in order to obtain the values of A, B, C, &c. Maclaurin's *Theorem* may be employed advantageously for the same purpose. Arbogast, in his *Calcul des Dérivations*, gives a general formula whereby these coefficients can be calculated with comparatively little trouble. In the *Penny Cyclopædia* the values of eleven of these coefficients and the law of their formation are given.

Revetment (Fr. revêtement). In Fortification, a facing to the steep sides of a ditch or parapet. In field works it may be of timber, turf, hurdles, gabions, &c.; in permanent works it is generally of masonry. In permanent fortification, when a portion only of the exterior of the rampart is revetted, the wall is called a *demi-revetment*. When the wall is carried up to the superior slope, it is called a *full revetment*; the latter is much more defensible against escalade.

Revetments have been constructed in four different forms, named from their profiles, *rectangular*, *leaning*, *sloping*, and *counter-sloping*. The first of these is a wall of equal thickness throughout; the second differs only in being inclined to the bank supported, so as more effectually to resist the pressure of the earth; the third has a greater thickness at the base than the top, its back being vertical, and its face sloping; the fourth has its back sloping, and face vertical. *Hollow* or *counterarched revetments* are those constructed with counter-arches, forming vaulted defensive galleries, or filled in with earth.

Review (Fr. revue). The name now commonly assumed, by literary usage, for periodical publications consisting of a collection of critical essays. The *Journal des Savans*, commenced at Paris in 1665 by M. de Sallo, is commonly cited as the first review properly so called. The most distinguished modern journals under the name of review in France are, the *Revue Encyclopédique*, the oldest of them (now extinct); the *Revue Française* and *Revue des Deux Mondes*; and the *Revue Britannique*, which consists of translations from the English. In England the *Monthly Review* (established in 1749) was the first publication of its kind. The establishment of the *Edinburgh Review* in 1802, followed by that of the *Quarterly* in 1809, may be said to have commenced a new era in criticism: from that time reviews have been adopted as the organs for conveying the opinions of sects and parties in religion and politics, as well as in literature. All the leading works of this description (the *Edinburgh*, *Quarterly*, *Westminster*, *British Quarterly*, *North British*, *Church of England*, *Christian Remembrancer*, and *Dublin*) now appear quarterly, or nearly so. The management of reviews in England is in the hands of an editor, whose name, however, does not appear, the publisher being the party responsible. The articles are generally anonymous. All these reviews adhere to their designation, the articles admitted being in the form of *reviews* on some work or works specified at the head, although, in point of fact, the latter are often not even noticed by the reviewer, his remarks being more in the form of a general essay than of a review. In this way they serve the purpose of affording governments or political parties the means of making statements of facts, or declarations of opinion, which do not involve them in the difficulties of direct responsibility, and yet are generally understood to convey their sentiments. The pay of writers in reviews is various, depending not only on the means of the review, but on the rules adopted by particular editors; for some have thought proper to equalise their rate of remuneration, others to retain in their own hands the power of estimating contributions according to their supposed value. The French *revues* are conducted on a different plan. Articles in general have the name of the contributor attached; and the form of a *review* is not preserved, tales, poetry, essays on the politics of the day, &c. being admitted indiscriminately. This plan has been adopted in some of the reviews recently issued in this country, as in the *Fortnightly Review*, *Macmillan's Magazine*, the *Contemporary Review*, &c. Besides France and England, reviews have been long established in the other European states, and in America; but this species of publication has taken the deepest root in Germany, where reviews may be said, without exaggeration, to appear daily, though none of them possess the influence of the leading English reviews. (Hallam, *Literary History*, pt. iv. ch. vii.)

Review. In Military language, an inspection of a body of troops assembled for that purpose by a royal personage or officer of high rank.

Review. In a Naval sense, a fleet or squadron passing through various manœuvres and evolutions, with perhaps a pretended battle.

Review, Bill of. In Law, a bill filed in order to procure an examination and alteration

of a final decree in Chancery duly signed and enrolled. If not enrolled, a petition of rehearing is the proper proceeding.

Review, Court of. A court of appeal from the Commissioners in Bankruptcy, established by stat. 1 and 2 Wm. IV. c. 56, and abolished by 10 and 11 Vict. c. 102.

Revise (Lat. revideo, *I see again*). In Printing, a second proof taken for examination by the first proof. A *press revise* is the final proof pulled before printing off the form of types.

Revivor, Bill of. In Law, a continuance of an original bill in a court of equity, when by death some party to it has become incapable of prosecuting or defending a suit, or a female plaintiff has incapacitated herself by marriage from suing alone. A bill *of revivor and supplement* continues a suit upon an abatement, and supplies defects which may have arisen from some event subsequent to the institution of the suit. In many cases an order of revivor may now be obtained without a fresh bill.

Revocation, Power of. In Law, a power contained in a deed, by which the grantor retains the liberty to revoke it. Wills are in their nature revocable, but deeds as a rule cannot be revoked unless power for that purpose is reserved.

Revolute (Lat. revolutus, part. of revolvo, *I roll back*). In Botany or Zoology, when a part is rolled outwards or backwards.

Revolution (Lat. revolutio). In Astronomy, this word is used to signify the motion of a secondary body round a primary one, as contradistinguished from *rotation*, which signifies motion round an axis. The *time of revolution* is the period in which a planet, satellite, or comet returns to the place in its orbit from which we estimate its setting out.

Revolution. In Mechanics, this term is synonymous with *rotation*.

Revolution, French (Era of the). In Chronology, this era was substituted for the Christian era in all public acts and documents, by a decree of the National Convention in 1793; and fixed at the 22nd of September, 1792, the day of the foundation of the French republic. It was abolished by Napoleon, and the Christian era restored in 1806.

Revolution, Surface of. In Geometry, a surface generated by the motion of a line, right or curved, around a fixed axis. Thus the surface generated by the motion of one right line around another is either a *cone* or a *hyperboloid of revolution* according as the two lines do or do not intersect each other. The motion of an ellipse around one of its axes generates an *ellipsoid of revolution*, which receives the name of *prolate* or *oblate spheroid* according as the major or minor axis remains fixed.

It is obvious that every sphere whose centre is in the axis must intersect the surface of revolution in circles whose planes are perpendicular to the fixed axis; so that the general equation of a surface of revolution is

$$(x-a)^2+(y-b)^2+(z-c)^2=F\,(lx+my+nz),$$

where a, b, c are the coordinates of any point in the axis; l, m, n are proportional to the direction-cosines of the latter, and F any functional symbol. The lines of curvature on a surface of revolution are plane curves. Those of one system consist of circles in planes perpendicular to the axis, those of the other system are the *meridian lines*, all equal to the generating curve, and situated in planes which intersect in the axis. The normal at any point of a surface of revolution also intersects the axis. The intercept upon it made by the axis and the surface is one of the principal radii of curvature, whilst the other coincides with the radius of curvature of the meridian line.

Revolution. In Politics, a word of somewhat indefinite meaning, but usually denoting an extensive change in the political constitution of a country accomplished in a short time, whether by legal or illegal means. The term *Revolution*, in English History, is applied by way of eminence to the political change effected in the year 1688, when William III. and Mary acceded to the throne on the forced abdication of James II.

Revolver. A term applied to a fire-arm with several chambers or barrels, which are brought successively under the action of the trigger, or percussion arrangement, so that several shots can be fired without the necessity of reloading.

Rex Sacrorum or **Rex Sacrificulus.** In ancient Rome, an officer answering to the archon basileus at Athens. [Archon.] On this officer those powers seem to have been conferred which the kings had possessed as priests of the nation. As no political influence was attached to the office, the plebs did not care to assert their claims to it, and the rex sacrorum was always elected from the body of the patricians. (Liv. ii. 2.)

Rhabarbarine. [Chrysophanic Acid.]

Rhabdologia (Gr. ῥάβδος, *a rod*, and λόγος, *a description*). The name given by Napier to a method of performing multiplication and division by means of a set of figured rods or scales. [Napier's Rods.]

Rhabdomancy (Gr. ῥαβδομαντεία). Properly, divination by a rod or wand. Some persons have been believed to be endowed by nature with a peculiar sense or perception, by which they are enabled to discover things hid in the earth, especially metals and water. But a more prevalent opinion has been that the discovery of these substances might be effected by means of a divining rod. The divining rod is a branch of a tree, generally hazel, forked at the end, and held in a particular way, by the two ends, in the hands of the adept; and is supposed to indicate the position of the substance sought by bending towards it with a slow rotatory motion, the adept, according to modern practice, being placed in contact with some metallic or other magnetic substance. The art is said to be occasionally practised in the south of France and Italy, under the names of *metalloscopy*, *hydroscopy*, &c. Campetti, an

Italian, in the beginning of the present century, excited much attention by his professed powers of rhabdomancy.

Rhadamanthus. In Mythology. [Minos.]

Rhætizite. A Mineralogical synonym of the Kyanite of the Tyrol (the Rhætian Alps).

Rhamnaceæ (Rhamnus, one of the genera). A natural order of arborescent or shrubby perigynous Exogens, inhabiting all parts of the world excepting the arctic regions. The berries of various species of *Rhamnus*, e.g. *R. catharticus*, are violent purgatives; while the fruit of some species, as *Zizyphus Jujuba*, the Jujube, is harmless and eatable. They are all small-flowered polypetalous or apetalous plants, with four or five stamens alternating with the lobes of the calyx.

Rhamnus (Gr. ῥάμνος). The typical genus of *Rhamnaceæ*, consisting of shrubs or small trees, mostly found in the temperate countries of the northern hemisphere. They are called Buckthorns, and furnish some useful dye plants. The most important commercial product of the genus is the dyeing material used by calico-printers, and known as Yellow-berries, or Persian berries, considerable quantities of which are annually imported from Asiatic Turkey, and from Persia by way of Trebizonde. These are usually ascribed to *R. infectorius*, but they are probably collected indiscriminately from several species—the unripe fruits alone being gathered. From the bark of *R. chlorophorus* and *R. utilis* the Chinese prepare their beautiful green dye, Lo-kao, called in this country Chinese Green Indigo. Large quantities of this Indigo have been imported into Lyons, and used for dyeing silks, the shades of green imparted by it being exceedingly beautiful, especially when seen under the influence of artificial light. A similar dye, however, has since been extracted from *R. catharticus*.

The indigenous Purging Buckthorn, *R. catharticus*, produces little shining black fruits, which resemble corns of black pepper when dry; these were formerly in great demand as a purgative medicine, and are still employed by rustic practitioners, but on account of the violence of their action they have deservedly fallen into disrepute, although Syrup of Buckthorn is still included in our pharmacopœias. The bark likewise possesses active purgative properties. The pigment known as sap or bladder-green is prepared by mixing the fresh juice of buckthorn berries with lime, and evaporating to dryness.

The wood of the Alder Buckthorn, *R. Frangula*, yields the best charcoal for making gunpowder; and the Alaternus, *R. Alaternus*, an evergreen shrub, is grown for ornamental purposes in gardens and shrubberies.

Rhamphastos (Gr. ῥάμφος, *a beak*). The name of a genus of Scansorial birds (*Túcans*) in the system of Cuvier, distinguished by an enormous beak, nearly as thick and as long as the body in some species. The compensation by which this disproportionate beak is rendered manageable and portable is an extremely light and cellular structure internally. It is arcuated near the extremity, and in old túcans is irregularly indented along the edges. The túcans are distinguished from the hornbills by the scansorial modification of their feet, in which two toes behind are opposed to two in front; and by their long, narrow, and ciliated tongue. They are confined to the hot climates of America, where they live in small flocks, feeding on fruit, insects, and the eggs and callow offspring of other birds.

Rhaponticin. [Chrysophanic Acid.]

Rhapsodist (Gr. ῥαψῳδός, from ῥάπτω, *I sew* or *stitch*, and ᾠδή, *a song*). A name given to the minstrels who recited the Homeric poems in Greece, especially before the period at which those poems were first committed to writing. (Grote's *History of Greece*, vol. ii. p. 174 &c.; Gladstone's *Homer and the Homeric Age*, i. 246; Max Müller's *History of Sanskrit Literature*, 502 &c.)

Rhatany (Peruv.). The astringent root of *Krameria triandra*. What is called Savanilla Rhatany is the root of a New Grenada variety of *Krameria Ixina*. [Krameria.]

Rhea (Gr. Ῥέα or Ῥεία). In the Hesiodic *Theogony*, a daughter of Ouranos and Gê (Heaven and Earth), and wife of Cronos, by whom she became mother of Hestia [Vesta], Demeter, Hera, Hades, Poseidon, and Zeus. In the existing Homeric poem she is only named once (*Iliad* xv. 187). At Athens, where the worship of this mother of the gods is said to have been first introduced among the Greeks, her temple was called the Metroum (Μητρῷον), i.e. the house of the mother. The etymology of the name Rhea seems doubtful.

Rhea. The name of a genus of Struthious birds, of which the three-toed ostriches of South America are the representatives.

Rhein. [Chrysophanic Acid.]

Rheometer (Gr. ῥέω, *I flow*; μέτρον, *measure*). A term proposed by Peclet as a synonym for *galvanometer*, and generally adopted by the French writers on physics. Professor Wheatstone, in an ingenious paper entitled 'An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit,' published in the *Philosophical Transactions* for 1843, uses the term, in a general sense, to designate any instrument for measuring the force of an electric current, without reference to its particular construction. Mr. Wheatstone also uses the following similar terms in describing apparatus employed in investigations on the same subject:—

Rheomotor (Lat. moveo, *I move*). Any apparatus which originates an electric current.

Rheoscope (Gr. σκοπέω, *I view*). An instrument for ascertaining merely the existence of a current.

Rheostat (Gr. ἵστημι, *I place*). An instrument for adjusting or regulating the circuit, so that any constant degree of force may be obtained.

Rheotome (Gr. τέμνω, *I cut*). An instrument which periodically interrupts an electric current.

Rheotrope (Gr. τρέπω, *I turn*). An instrument which alternately inverts the current.

Rheophore (Gr. ῥέω, and φορέω, *I bear along*). A term employed by Ampere to designate the connecting wire of a voltaic apparatus, as being the carrier or transmitter of the current.

Rhetoric (Gr. ῥητορική, sc. τέχνη, *the rhetorical art*; from ῥήτωρ, *an orator*). In the widest sense in which the word is occasionally used by modern writers, the art of prose composition generally. In the most restricted and most etymological sense, the art of oratory, or of addressing public assemblies. In an intermediate sense, in which, perhaps, it is most commonly employed, the art of argumentative composition. This comes nearest to the signification which Aristotle, the earliest extant writer of a formal treatise on rhetoric, attached to the title of his subject, when he defined it to be the art of discovering and employing topics of persuasion. He arranged these topics or means of persuasion under three heads. First, those which arise from the character of the orator himself; i. e. the character in which, by what must be termed rhetorical artifice, he places himself before his hearers. It is obvious that a speaker addressing an assembly, who is known by them to be actuated by honest motives, and to understand the subject on which he speaks, advances by the mere possession of these adventitious attributes a long way towards the end and aim of oratory, viz. persuasion. Hence it is that Aristotle presents, as one of the chief branches of rhetoric, the art by which the speaker or writer, as it were, invests himself with these attributes, and thus insures a more favourable reception to his argument. The art of moving the passions by the use of such arguments and representations as are proper to excite each belongs also, in Aristotle's arrangement, to this division of his subject. In his second division he treats of argument itself, considered with respect to its cogency or inconclusiveness in point of form; and hence logic, in this point of view, becomes ancillary to, or a subdivision of, rhetoric. The third division of the subject exhibits the modes of persuasion arising from style, arrangement, delivery, and action; and to this third branch writers who have treated of rhetoric in its more limited sense have usually confined themselves.

As the work of Aristotle is the first, so it is the only systematic treatise on rhetoric which the ancients have left us, among whom the art was much more diligently cultivated than among the moderns. Public speaking was of infinitely greater importance in the classical commonwealths than in any modern state; even in our own, where it is most studied and valued, it is but a subsidiary accomplishment. The true momentum of decision, that which convinces or dissuades, lies in the pen of the writer rather than in the voice of the orator; and whilst in the Grecian republics assemblies were actually swayed by oratory to determine on a particular course of action, its principal use now appears to be to arraign, to vindicate, or to explain the actions of individuals. French oratory, from the nature of its subject, is and always was confined within narrow limits. Probably pulpit oratory, in modern European society, answers most nearly to the classical notion of rhetoric; and, had it ever been subjected to systematic rules, would have been found most nearly to conform to those which the ancients have left us. Among the Romans, oratory did not begin to be cultivated as a science until just at the period when its political importance was about to cease. Rhetoric, under the Roman empire, was taught as a regular science; but its practical display was confined to the orators of the forum, among whom the art gradually declined, from the tendency of the civil law, during the last period of its developement, to conduct all process by written rather than oral method. On the other hand, the rules of rhetoric were applied to the construction of declamations, a species of fictitious argument much in vogue during the decline of Roman literature; and of panegyrical harangues. The study of rhetoric, in this perverted sense of the word, i. e. of declamatory speaking or writing, found peculiar favour in the African and Oriental schools of the Roman empire. Some of the early Christian writers, especially Tertullian, afford evident tokens of having acquired the art of composition under such discipline. [ELOQUENCE.]

Rheum (Gr. ῥεῦμα, from ῥέω, *to flow*). A genus of large-growing herbs of great importance in medicine, as the source of the Rhubarb of the shops, and also of considerable culinary value as the source of the Rhubarb of the garden. [RHUBARB.] The former consists of the root of the plants, which is dug, washed, and sun-dried, and then carefully assorted for exportation, its value depending very much on the nature of the climate in which it is produced. It is supposed to be the produce of *R. palmatum*. The latter consists of the succulent leaf-stalks of garden varieties of *R. Rhaponticum* and *R. undulatum*, the latter yielding the delicate-flavoured rhubarbs with red stalks. Though in Queen Elizabeth's time the leaves of Rhubarb were used as a potherb, it was not until the beginning of the present century that the tender leaf-stalks came to be employed for tarts, and were found so valuable for various other culinary preparations. They are excellent, either stewed alone, or with rice; and a capital preserve has been made from them. When too large and old for cooking, they undergo a process by which the juice is expressed from them and made into a delicious wine similar to that from green gooseberries, and closely resembling champagne; indeed, it may be suspected that much of the so-called champagne commonly drunk is no other than a preparation from the stalks of Rhubarb. The juice is stated to contain a large amount of oxalic acid, as well as nitric and malic acid; and it is these which give an agreeable taste to the stalks when cooked, but which render them ill suited to persons of weak digestion.

In the *Gardener's Chronicle* for 1846 (p. 5) Mr. A. Forsyth first directed attention to another part of Rhubarb as being suited for culinary purposes, and to which he gave the name of *Rhaflower*. This is the large globular pouch of unopened flowers, which is described as being of a beautiful colour when dressed in the same manner as Rhubarb, of a milder flavour, and forming altogether a dish of great delicacy.

Rheumatism (Gr. ῥευματισμός). A painful affection of the joints, attended by swelling or stiffness, and affecting chiefly the tendinous and fibrous textures. It is occasionally accompanied by fever, thus becoming *acute rheumatism*, or *rheumatic fever*; in which case the joints are much swollen and excessively painful; the pulse frequent, but seldom hard; the perspiration usually abundant and acid; the tongue extremely foul, and the bowels costive; headache is seldom complained of, and delirium very rare. In this form of the disease a translation or metastasis to the heart is not uncommon. The treatment consists in the use of purgatives, diuretics, and alkalies. Lemon juice has also been used with advantage in acute cases, and opium in large doses is with some a favourite mode of treatment. *Chronic rheumatism* is not in general attended by any very remarkable constitutional symptoms. It occasionally leads to permanent distortion of the joints; affects the periosteum, tendons, and ligaments; and is most common in debilitated habits, when the health has been broken by previous disease or over-exertion of body or mind. These cases come more properly under the head of rheumatic goût. Opium, especially in the form of Dover's powder, is often useful in this disorder to procure rest. The bowels should be kept moderately active by warm purges, and tonics and alteratives cautiously administered. A course of sarsaparilla is often extremely serviceable: colchicum has been resorted to, but with most uncertain success.

Rhinanthus (Gr. ῥίς, ῥινός, *a snout*, and ἄνθος, *a flower*). A genus of annual weeds growing in pastures, the common species, *R. Crista galli*, being known as the Yellow Rattle. They belong to the *Scrophulariaceæ*.

Rhine, Confederation of the. A confederation formed in July 1806 between several princes of the south and west of Germany and the French emperor Napoleon, who was constituted the protector of these states when the latter had separated themselves in perpetuity from the Germanic empire.

Rhinocarpus (Gr. ῥίς, and καρπός, *fruit*). A large tree of Columbia, New Grenada, and British Guiana, belonging to the order *Anacardiaceæ*. It is known in Guiana as the Wild Cashew, and in New Grenada as Caracoli, and yields an excellent tough durable timber, and a pleasant edible fruit. In Panama, according to Seemann, the tree is called Espave, and its bark is said to be used in stupefying fish.

Rhinoceros (Gr. ῥινόκερως, literally *nose-horn*). The name of a genus of Perissodactyle Pachydermal mammals, characterised by one or two horny productions upon the nose. A species of horn-bill is also called rhinoceros, on account of the remarkable recurved horny process which rises from its upper mandible. Six or seven species of rhinoceros now exist, confined to Africa and South-Eastern Asia. In the later tertiary period an equal number of species existed; and in the middle tertiary we have evidence of a hornless form, *Acerotherium*, allied to Hyrax.

Rhinolophus (Gr. ῥίς, ῥινός, *nose*, and λόφος, *crest*). A genus of Entomophagous Cheiroptera in which the nose is prolonged upwards into a cordate or semicircular leaf. The genus is peculiar to the eastern hemisphere. The Horseshoe bat (*Rhinolophus ferrum equinum*) is found in the South of Europe. The *Rhinolophus hippocrepis* has been observed in England.

Rhipipterans (Gr. ῥιπίς, *a fan*; πτερόν, *a wing*). A name proposed by Latreille to supersede that of *Strepsiptera*, by which Kirby designated a new order of insects which he had discovered. The new name has nothing to recommend it, since it signifies a character, founded on the presence of pterygoda, common to other orders of insects, as the Lepidopterans.

Rhizantheæ (Gr. ῥίζα, *a root*; ἄνθος, *a flower*). A class of plants occupying a station between sexual and asexual species, and appearing to be an intermediate form of organisation between Endogens and the lower orders of vegetation. They agree with the former in the presence of sexes, and in their flowers having sometimes a ternary structure; but they have scarcely any spiral vessels, and their seeds appear, as far as they have been examined, to consist of a mass of spores, without a special embryo. In their succulent texture, in their colour, often in their putrid odour when decaying, in the sporuliferous seeds, and in their parasitical habits, these plants resemble *Fungi*; while in their flowers and sexes they accord with *Araceæ*, or similar Endogens. They are in all cases parasites, and destitute of proper leaves, in lieu of which some of them have scales imbricated over their stems. Notwithstanding their parasitical habits, some are of extraordinary size; the flowers of *Rafflesia Arnoldi* are as much as nine feet in circumference.

Rhizobolaceæ (from Rhizobolus, a synonym of Caryocar, the principal genus). A small order of Hypogynous Exogens of the Guttiferal alliance, consisting of tropical American trees. They are proposed by some botanists to form a tribe of the *Ternströmiaceæ*, differing from the other sections of that order, and the allied *Clusiaceæ*, by their digitately compound leaves. The Saouari nuts of the shops, one of the most delicious seeds of the nut kind, are the produce of *Caryocar nuciforme* and *C. butyrosum*, which latter also yields an excellent timber. [CARYOCAR.] The chief features of the order are the digitate leaves, symmetrical flowers, equilateral petals, sessile

stigmas, and solitary seeds, the embryo of which has an enormous radicle.

Rhizoma (Gr. from ῥίζα, *a root*). In Botany, the term applied to a perennial form of stem, which is prostrate and rooting, throwing up leaves progressively. The common garden *Iris* affords a good example of a rhizome.

Rhizophoraceæ (Rhizophora, one of the genera). A natural order of the Myrtal alliance of Epigynous Exogens, found on tropical shores, where they root in the mud, and form a close thicket down to the verge of the ocean. They are distinguished by their polypetalous flowers, valvate calyx, indefinite stamens, many-celled ovary, and flat cotyledons. The principal genus is the Mangrove, *Rhizophora Mangle*, a tree which performs a most important part in the economy of Nature, wresting annually fresh portions of the land from the dominion of the ocean, and adding them to the domain of man. This is effected in a twofold manner: by the progressive advance of the roots, and by the aërial germination of the seeds, which do not quit their lofty cradle till they have assumed the form of actual trees, and then drop into the water with their roots ready prepared to take possession of the mud, in advance of their parent stems. The progression by means of the roots is effected by the new roots issuing from the trunk at some distance above the surface of the water, and arching downwards so as to penetrate the mud, thus establishing themselves as the pioneers of fresh invasions of the retiring element. In this manner the young plants, soon after their descent from the parent trees, continue during their early years to advance steadily forward, till they have attained a height of about fifteen feet, and gained a position considerably in advance of their parent trunks. After this, fewer additions are made to the roots, but the head begins to expand in every direction, spreading its branches on all sides. These branches in their turn send down long slender roots, like those of the banyan-tree, which rapidly elongating descend from all varieties of height, and reaching the water penetrate the mud, becoming independent trees. These mangrove-bogs are the certain indicators of a malarious locality, as they prevent the escape of unhealthy miasma. The trees contain tannin, and the bark has been used medicinally as an astringent. The fruit is said to be sweet and edible, and the fermented juice to be made into a kind of light wine.

Rhizostomes (Gr. ῥίζα, and στόμα, *a mouth*). A genus of *Medusæ*, including those which have the absorbing orifices of their nutrient canals of small size, and situated in great numbers on the branches of arms, or peduncles, extending from the centre of the inferior surface of the disc.

Rhodalose or **Rhodhalose** (Gr. ῥόδον, *a rose*, and ἅλς, *salt*). Red or cobalt vitriol. [BIEBERITE.]

Rhodanic Acid (Gr. ῥόδον). A Chemical synonym of sulphocyanic acid. It produces a red colour with persalts of iron.

Rhodes Wood. One of the names of the West Indian Candlewood, *Amyris balsamifera*.

Rhodium (Gr. ῥόδον, on account of the rose-red colour of some of its salts, especially of the chloride, when dissolved in water). A metal discovered in 1803, by Wollaston, associated with palladium in the ore of platinum. It is of a whitish colour, very difficult of fusion and very hard. Its specific gravity is 12·1, and its atomic weight 52·16. It is represented by the symbol R. It has been used for the points of metallic pens. [PLATINUM.]

Rhodizite (Gr. ῥοδίζειν, *to make red*). A species of Lime-Boracite, which, when heated before the blow-pipe, colours the flame, first green, but afterwards red. It is found, in minute translucent and shining crystals, which are white or inclining to yellow or grey, near Mursinsk in the Ural.

Rhodizonic Acid. A substance formed by passing dry carbonic oxide over highly heated potassium, and acting on the product by water. A red powder separates, which is rhodizonate of potassa, from which rhodizonic acid may be separated by a mixture of sulphuric acid and alcohol. Its formula is said to be $C_{10}H_4O_{12}$.

Rhodochrome (Gr. ῥόδον, and χρῶμα, *colour*). A massive or scaly variety of Kämmererite of a greenish-black colour, found in the island of Tino, in Greece; in the Ural, and at Kraul in Styria.

Rhodochrosite (Gr. ῥοδόχροος, *rose-coloured*). A carbonate of protoxide of manganese, in which the latter is often partly replaced by lime, magnesia, and protoxide of iron. [DIALLOGITE.]

Rhododendron (Gr. ῥόδον, *a rose*, and δένδρον, *a tree*). A genus of evergreen shrubs of the order *Ericaceæ*, remarkable no less for their beauty than for the great variety of aspect which they present. They have monopetalous flowers, varying from bell-shaped to almost flat on the one hand, and narrowly tubular on the other, and in almost all cases produce large showy blossoms, frequently in massive heads. The most important race, so far as garden decoration is concerned, is that consisting of hardy flowering evergreens, which in early summer light up our shrubberies and American gardens with a blaze of brilliant colours. These have been chiefly bred from *R. maximum*, *catawbiense*, and *ponticum*, intercrossed with some of the high-coloured tender kinds. Many Indian species form magnificent conservatory plants, only just too tender to thrive unprotected in our climate. Of these, *R. arboreum* is the best known, and has contributed by hybridisation in no small degree to enrich the colours of the hardy sorts. Many of the tender sorts are deliciously fragrant. The flowers of *R. Edgeworthii* in particular are so fragrant that a few are sufficient to scent a large room.

In the size attained by the species there is a wide contrast. The small and humble *R. lapponicum* is a prostrate shrub, with branches a few inches long; while *R. Falconeri* is sometimes fifty

feet high, with leaves nineteen inches long. The genus is also widely diffused: *R. lapponicum* occurs in the arctic zone; *R. maximum* and *R. catawbiense* are plentiful in some parts of North America; representatives occur in Europe and in China; but the greatest number are found in India, and in the islands of the Eastern Archipelago.

The properties of the *Rhododendron* family are to be looked on with suspicion. It is long since poisonous qualities were first attributed to honey collected by bees from flowers of *R. ponticum*, and the same is reported of some Indian species. Notwithstanding this, an edible jelly is prepared in India from the boiled-down flowers of *R. arboreum*. Goats are said to die after eating the leaves of *R. cinnabarinum*; and the wood, when used as fuel, produces swellings of the face, and inflammation of the eyes. The Siberian *R. chrysanthum* is narcotic.

Rhodoise or **Rhodonite** (Gr. ῥόδον). A silicate of manganese or Manganese-Augite, composed of 54·1 per cent. of protoxide of manganese and 45·9 of silica. It occurs, generally in crystalline and granular masses of a rose-red or reddish-brown colour, south-east of Callington in Cornwall, and at Upton Pyne and Black Down in Devonshire; also in Sweden, Siberia, the Harz, and New Jersey. Rhodonite is sometimes used in a polished state for inlaying. [Allagite.]

Rhodorhiza (Gr. ῥόδον, *a rose*, and ῥίζα, *a root*). A genus of *Convolvulaceæ*, consisting of two small woody plants, found only in the Canary Islands, and by some retained in the genus *Convolvulus*. They are named *R. scoparia* and *R. florida*. The genus derives its name from the rose-like smell peculiar to the root-stock and lower part of the stem, which yield a kind of Rosewood (*lignum rhodii*), from which is distilled the powerfully-scented oil known as *Oleum ligni Rhodii æthereum*, used in some countries for ointment, but more frequently for the adulteration of attar of roses. This Rosewood is called by the French Bois des Rhodes des Parfumeurs, and must not be confounded with the so-called Rosewood of commerce used for furniture. [Dalbergia; Rosewood.]

Rhomb Spar. A crystalline magnesian carbonate of lime. [Bitter Spar.]

Rhombus and Rhomboid (Gr. ῥόμβος, ῥομβοειδής). In Geometry, a parallelogram whose angles are not right angles is called a *rhombus* when its sides are all equal, and a *rhomboid* when this is not the case.

Rhonchus (Gr. ῥόγχος). A rattling or wheezing sound: the term is chiefly applied to sounds occasioned by certain morbid states of respiration, as indicated by the stethoscope.

Rhubarb (Lat. rha barbara, Gr. ῥᾶ). The root of the *Rheum palmatum*, and perhaps some other species, cultivated in Thibet and China for the supply of the drug market. The varieties of rhubarb known in commerce under the names of Russian, Turkey, and Indian rhubarb, are all derived from one source; but the select pieces are sold under the name of Russian and Turkey rhubarb, and those of somewhat inferior quality as East Indian. The varieties found in commerce are very numerous; some are cultivated even in Europe. To judge of the quality of rhubarb, it should be cut or broken: when good, it is of good specific weight, of a mottled reddish or brownish red colour; that which is very pale or very dark coloured, and either so soft as to be spongy, or hard and stony in texture, is bad.

Rhubarb is a valuable article of the *Materia Medica*, being an aperient, and at the same time a tonic and astringent. The average dose of powdered rhubarb, which is twenty grains, leaves after its purgative operation a certain astringent effect upon the bowels; hence its use in diarrhœa: from five to ten grains operates as a tonic, and is very useful in some forms of dyspepsia. A mixture of one part of rhubarb with two of powdered sulphate of potash is an excellent aperient for children. It is occasionally given as a tincture or infusion; but the powder is the favourite form, either in a little plain, or peppermint, water, or in the form of pill. For a full account of the varieties of rhubarb and their respective analyses, the reader is referred to Pereira's *Materia Medica*. [Rheum.]

Rhumb Line (Gr. ῥύμβος, the Attic form of ῥόμβος). In Naval affairs, the track of a ship which cuts all the meridians at the same angle; called also the Loxodromic Curve. This, being the simplest curve, is the route universally pursued; but a ship sailing on this curve never looks direct for her port until it comes in sight.

Rhus (Gr. ῥοῦς, Lat. rhus). A large genus of *Anacardiaceæ*, found abundantly in the temperate countries of both hemispheres. They are for the most part shrubs, and possess poisonous properties of a more or less marked character. Indeed some American species, such as *R. venenata* and *R. Toxicodendron*, produce effects almost rivalling those once fabulously imputed to the Upas-tree of Java (*Antiaris*), the hands and arms of some persons, and sometimes even the whole body, becoming much swollen from simply touching or carrying a branch of one of them, the swelling being accompanied with intolerable pain and inflammation, and ending in ulceration. These effects, however, are not felt by everyone, some persons being able to handle the plants with impunity.

A few of the species yield useful products, such as *R. Coriaria*, the Tanning Sumach, which affords commercial Sumach. This plant is a native of the European countries bordering the Mediterranean, and when allowed to grow to its full size attains a height of fifteen or twenty feet; but in a cultivated state the young shoots are cut off annually for the sake of their leaves, and it is consequently seldom seen higher than four or five feet. The Sumach of commerce consists of the finely ground young leaves: it is extensively employed for tanning and dyeing purposes, from 12,000

to 18,000 tons being annually imported, chiefly from Sicily. *R. Cotinus*, another South European species, called the Venus or Venetian Sumach, yields the yellow dye-wood called Young Fustic, which in olden times was supposed to be the young branches of the true Fustic-tree (*Maclura*).

The Japan Wax recently brought in considerable quantity to this country is the produce of the fruits of *R. succedanea*. *R. vernicifera*, another small Japanese tree, yields the famous lacquer so extensively employed by the inhabitants of that country for lacquering various articles of furniture and small-ware. It exudes from wounds made in the tree, and is at first milky-white, but becomes darker and ultimately black on being exposed to the air. Nothing certain is known respecting the mode of preparing it for use, and it is said that the Japanese themselves have lost the secret of its preparation, for the lacquer-ware at present manufactured is greatly inferior to the ancient.

Rhyme (A.-Sax. gerim, Ger. reim). In Poetry, the correspondence of sounds in the last words or syllables of verses. The latter is the true rhyme of modern European languages. There are rhymed verses in the Latin classical poets, where the jingle seems intentional, and more distinct examples of it in the fragments of Roman military songs, &c. which have come down to us. But in the earlier period of the decay of the Latin language, when accent was substituted for metre in the rhythmical arrangement of the verse, rhyme made its way into the composition of church hymns, &c. It has been attempted, but with little success, to deduce this innovation from the Goths, and from the Arabians; but the former, like the old Teutonic races, probably used alliteration but no rhyme in their verses; and the latter could not have influenced European literature until a period long after that in which rhyme first appears. It has been proved, beyond the possibility of doubt, that rhymed Latin verse was in use from the end of the fourth century. (Hallam, *Literary History*, part i. ch. i. § 35.) A rhyme in which the final syllables only agree (*strain, complain*), is called a *male* rhyme; one in which the two final syllables of each verse agree, the last being short (*motion, ocean*), *female*; and the latter is sometimes extended in Italian poetry to three syllables (*femore, immemore*), when the verse is called *sdrucciolo*. In English such a license is hardly permissible, except in burlesque poetry (see *Hudibras* and *Don Juan* for instances). By the strict rules of French prosody, the male and female species of rhymes must be alternately used, however intricate the disposition of the verse may be, although the last short syllable is generally mute, or very slightly sounded. Rhymes which extend not only beyond the last three syllables, but through the whole structure of the lines, are used in Arabian and Persian poetry. Rhymes in which the consonants of the last syllable in each verse are identical (*dress, address*) are vicious in English, but rather admired in French poetry. One more singularity of English poetry deserves notice. While from the irregularity of our spelling many syllables rhyme with each other although widely dissimilar in orthography (*woo, pursue*), there are, on the other hand, rhymes which speak to the eye, and not to the ear; i. e. in which the orthography of the rhyming syllables is the same, but the pronunciation different; as *wind, find*; *gone, alone*. In the following triplet of Dryden—

'Tis nothing yet; then poor and naked come,
Thy Father will receive His unthrift home,
And thy blest Saviour's blood discharge the mighty sum—

it will be seen that the first and third lines rhyme in a legitimate manner, although the last syllables are differently spelt; while the first and second rhyme to the eye only, and not to the ear. This is a license rendered admissible only by precedent.

Rhynchophores (Gr. ῥύγχος, *a snout*, and φέρω, *I carry*). The name of a family of Coleopterous insects, comprehending those which have the head prolonged in the form of a snout or proboscis.

Rhynchosaurus (Gr. ῥύγχος, and σαῦρος, *lizard*). A genus of Cryptodont Reptiles from the new red sandstone (trias) of Shropshire. The remains indicate a lizard-like animal with the most remarkable shaped cranium, which was edentulous, and resembled that of a bird or turtle. The premaxillary bones were produced downwards in the form of a beak, over the lower jaw, as in *Dicynodon*. Unlike that genus, however, there is no trace of any canine teeth in the upper jaw. The indications of the locomotive extremities denote an animal adapted for motion on land as well as in water.

Rhythm (Gr. ῥυθμός). The consonance of measure and time in poetry, prose composition, and music and by analogy in dancing. Each verse or each period may be considered as a whole, in which the poetical rhythm is regular and exact, within certain limited variations, the rhetorical less perfect, and the pleasure derived from it rather matter of taste and experience than of rule. Those parts which receive the ictus or stress of the rhythm are termed *arsis* (elevation), the remainder form the *thesis* (depression); the former is frequently denoted to the eye by the accent marked ʹ, when in a foreign or unknown word we wish to direct the voice in pronunciation to employ the correct emphasis. The smallest rhythmical division is the foot, by which every union of arsis and thesis is understood. A short syllable is an original unit of time; a long syllable contains two units. The number of feet enumerated in classical writers on metre amounts to twenty-eight, including all the varieties which may be formed out of two, three, or four syllables, long and short, and varying from two to eight units of time. [Foot; Metre; Rhyme.]

Rhythm. In Physiology, the more or less

regular succession of the contractions of certain automatic muscles. In the heart the motion commences in the venæ cavæ, and proceeds through the auricles and ventricles, and then, after an interval, is resumed in the venæ cavæ. In the intestine the movement travels in a vermicular manner from above downwards; and a second movement, beginning at the upper part of the intestine before the first has completed its course, affects the parts in the same order. These movements are called *rhythmic*; those of the intestinal tube are also called *peristaltic*.

RHYTHM. [MUSIC.]

Rial. A gold coin current in the reigns of Henry VI. and Elizabeth: under the former its value was ten shillings, under the latter fifteen shillings.

Rial or **Real.** A Spanish coin. [MONEY.]

Rib (Ger. rippe). The rib of a ship answers in many respects to the rib in an animal frame. The base of the rib is in the keel as a backbone, and it serves to maintain generally the cavity of the vessel. A rib is of massive timber in several pieces scarfed or chocked together. These pieces beginning from the bottom are the cross piece or floor, futtocks, top-timbers, and, if the vessel be of great height, the lengthening pieces. The ribs are otherwise known as the *timbers*.

RIB. In Botany, the principal vein or nervure which proceeds from the petiole into the blade of the leaf.

Ribs. In Anatomy, the lateral appendages of a vertebra, especially when developed so as to encompass the trunk. In the human subject there are twelve pairs of ribs, which, in general homology, are the *pleurapophyses*, the sternal cartilages being the *hæmapophyses*, and the sternum the *hæmal spine*.

RIBS. In Architecture, curvilinear timbers to which, in an arched or coved plaster ceiling, the laths are nailed.

Ribaudequin (Low Lat. ribaudequinus, perhaps from ribaud, ribaudaille—Eng. ribald—the name used to denote all the humbler classes of foot soldiers). A mediæval engine of war, consisting of a cart armed with iron spikes, and after the fourteenth century furnished with small cannon. Such engines are mentioned in the year 1382, as being placed in front of troops arrayed in order of battle. (Christine de Pisan, *Livre des Faits d'Armes*, ch. xxvi. fol. 36; Monstrelet, ch. lxxxiv. p. 206; Brackenbury, *Ancient Cannon in Europe*, p. 36.)

Ribband Shores. Strong supports for the frame of a ship during building. Their heads rest against the ribbands, and their bases on the slip or dock.

Ribbands. In Shipbuilding, longitudinal bands of comparatively thin timber stretching from stem to stern at different distances from the keel. They are bolted on outside the ribs, in order to preserve the proper curvature and to impart stability to the vessel while yet in skeleton.

The ribbands of the slip are square timbers fastened lengthways on the bilgeways, to prevent the timbers of the cradle from slipping outwards during launching.

Ribbon Jasper. A name given to those varieties of Jasper in which the colours are arranged in parallel layers or stripes. The principal localities are Saxony and the Ural; but it is also found in this country near Tortworth in Gloucestershire; in the Pentland Hills; at Arthur's Seat, Edinburgh; in the isles of Islay and Rum, &c. Ribbon Jasper is, in general, a result of the alteration of argillaceous strata by contact with igneous rocks.

Ribes (the Arab name of an acid plant, now ascertained to be *Rheum Ribes*). The botanical name of the genus which yields us the Gooseberry and Currant, whose succulent berries are well known. There are, besides, numerous ornamental flowering shrubs of the same family.

The Gooseberry, *R. Grossularia*, is indigenous to this country, as well as to many other parts of Europe, and has been found, according to Royle, in Nepal. It will ripen in Norway as far north as 66½°, nearly 16° north of London, but will not succeed so far to the south, for even in southern parts of England, under a hot sun, the fruit of some of the varieties becomes as if parboiled. The cooler climates of the North of England and Scotland suit it best. It is an important fruit, furnishing abundantly to millions of the manufacturing population materials for tarts, pies, sauces, &c. at an early period of the season, before any other fruit can be had for these purposes. By competition for prizes in Lancashire and the adjoining counties, the size of the berries has been enormously increased, although some of the old sorts, such as the Red Champagne, are yet unsurpassed in quality. The varieties are exceedingly numerous.

The Currant, *R. rubrum*, is indigenous to Central and Northern Europe, including Britain, Siberia, and Canada. It is to be found wild as far north as Finmark, but, like the gooseberry, it is not suited for so warm a climate as the South of Europe, otherwise it would have extended into Italy, and would have become known to the Greeks and Romans, which does not appear to have been the case. The English name of Currant may be attributed to the similitude of the fruit to the Corinth or Zante Grape, the currant of the shops. Improved varieties of the Currant appear to have been introduced from Holland, and the Red Dutch and the White Dutch are amongst the best in cultivation at the present day. These fruits are always in demand for making wine, tarts, jellies, jams, &c., and the quantities grown for that purpose have greatly increased since the price of sugar has become reduced. The refrigerant juice is also very grateful to the parched palates of persons suffering from fever. The Black Currant, *R. nigrum*, is a fruit much prized for domestic use, both as a preserve and as medicine.

Ribhus. In Mythology. [ORPHEUS.]

Riccati's Equation. An important ordinary differential equation, of the first order

and degree, first investigated by the Italian mathematician Riccati. It is usually expressed in the form

$$\frac{dy}{dx} + ay^2 = bx^n,$$

and is always solvable by a series of double transformations of the form

$$y = \frac{1}{ax} + \frac{1}{zx^2},$$

when n has the form

$$\frac{-4i}{2i \pm 1}$$

where i is either 0 or a positive integer. The equation becomes *linear* by assuming

$$y = \frac{1}{av}\frac{dv}{dx},$$

and to it may be reduced several other differential equations of greater generality. (Boole's *Differential Equations.*)

Ricciaceæ. [HEPATICÆ.]

Rice. [ORYZA.]

Rice Paper. The produce of the *Aralia papyrifera*, a low shrub, with large leaves, from Formosa, where it is wild and abundant. The trunk and branches resemble those of the elder. The pith, dried and rolled or hammered, and pared by sharp knives, forms the paper. It is dyed of different colours, and large sheets are obtained by pressing the smaller pieces together. It is usually sold in small squares of about four inches made up into packets of 100 each, a bundle of five packets being sold for 4*d*. (Swinhoe, *Pharmaceutical Journal* vi. 52.)

Ricinoleic Acid. One of the acids resulting from the saponification of castor oil.

Ricinus (Lat. *a tick*). The best known species of this genus of *Euphorbiaceæ* is *R. communis*, the seeds of which yield Castor-oil. The plant is a native of India, but is now widely distributed over the warmer regions of the globe and throughout the Mediterranean region. It is cultivated with us as an annual, and is known under the name of Palma Christi. In this country the stems do not attain a height of more than from three to five feet; but in Spain, Crete, Sicily, and elsewhere, the plant is stated to become a small tree. There are several varieties of this plant, differing in sundry slight particulars, and amongst others in the size of the seeds. These latter are oval, flattened, of a greyish colour mottled with brownish blotches. The best oil for medicinal purposes is derived from the small seeds, that procured from the large seeds being coarser, and in India employed for lamps and in veterinary practice. The oil is extracted by boiling the seeds and by pressure in an hydraulic press, the latter process yielding the most esteemed oil.

Rickets. [RACHITIS.]

Ricochet Fire (Fr. ricochet). In Gunnery, the fire of a battery placed at right angles to the line of troops or works aimed at; the guns being fired with reduced charge and considerable elevation, so as to give the shot a low velocity and a high curve, in order that it may be brought down immediately after clearing the crest of the parapet, and then by rebounding along the face of the work, dismount the guns or rake the line of troops under cover. It was invented by Vauban, and first employed at the siege of Haarlem in 1572. It arrived at perfection at the siege of Ath in 1697. It gave superiority to the attack over the defence of fortresses.

Riddle. [ENIGMA.]

Rider. A term used to signify any addition to manuscripts or other documents, inserted after their completion.

RIDER. A term used by miners to denote a deposit of ore overlying the principal mineral.

Riders. In Shipbuilding, riders were formerly internal ribs or timbers worked from the kelson as high as the lower deck, to impart greater firmness to the ship's frame. These riders restricted the space in the hold, and have now been generally superseded by bands of iron fastened diagonally on the inside of the ribs.

Ridge (A.-Sax. hricg, Ger. rück). In Architecture, the upper horizontal timber in a roof, against which the rafters pitch.

Riding. The three divisions of the county of York are so termed, by a corruption of the Saxon word *trithing* or *triding* (third part).

Riding Bitts. On Shipboard, massive frames of wood and iron round which the cable is coiled when the vessel rides at anchor. The bitts are bolted through two decks. Large vessels have two pairs: smaller vessels one pair. In inconsiderable merchant ships the windlass is made to do duty for riding-bitts.

Riding Master. A commissioned officer in regiments of cavalry and brigades of royal artillery. He holds the relative rank of lieutenant.

Ridotto (Ital.). A favourite public Italian entertainment, consisting of music and dancing; held generally on fast eves.

Riemannite. A Mineralogical synonym for Allophane, after Riemann, by whom it was first noticed.

Rifacimento (Ital. *re-establishment*). A term in common literary use applied to any work or treatise, the materials of which have not been derived from original research, or collected for the first time.

Rifle. [GUN; RIFLED GUNS; SMALL ARMS.]

Rifle Pits. Holes or short trenches, generally about four feet long and three feet deep, forming, with the earth thrown out in front of them, cover for two men. There is generally a loophole on the top of the breastwork, made by placing two sand-bags with a third resting on them, so as to cover the head and shoulders of the rifleman.

Rifle Regiments. Although the whole of the infantry of the British army is now armed with rifles, the rifle brigade and 60th regiment, which were armed with rifles while the other troops had only smooth-bored muskets,

are still distinguished as rifle regiments, as are also the Ceylon, Cape, and Canadian regiments.

Rifled Guns. Guns in which two or more spiral grooves are cut in the surface of the bore.

The groove of a rifled gun is simply a portion of the thread of a female screw with a long pitch. If A B C be a right-angled triangle (fig. 1), in which BC equals the circumference of the bore of the gun, and A B the length of the bore—suppose the triangle A B C wrapped round the surface of the bore, as in fig. 2, then A C is the *helix* or curve of the groove. But in most rifled guns the *twist*, or inclination of the grooves, is much less than one turn in the length of the bore, and is measured in terms of the length in which one turn is completed. When A C is a straight line, as in fig. 1, the twist is *uniform*; but if A C be curved, as in fig. 3, the groove will have an *increasing* or *gaining* twist, the *angle of twist* C A B becoming greater towards the muzzle. In this case the projectile is easily started, gaining a greater velocity of rotation as it proceeds towards the muzzle of the gun.

Fig. 1.

Fig. 2.

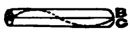
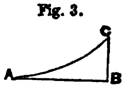


Fig. 3.



The object of rifling a gun is to give the projectile a rotation round an axis coincident with that of the bore. This insures greater accuracy of fire. If a spherical projectile be employed, no other advantages follow; but if an elongated projectile be used, as it can be when thus given a rotation round its longer axis, not only is accuracy increased, but we gain all the other advantages due to this form, which have been described in the article PROJECTILE. Elongated projectiles have, therefore, entirely superseded spherical projectiles for rifled guns.

Both small arms and cannon are rifled; but many difficulties occur in the construction of rifled cannon which are not met with in small arms; especially that of obtaining guns strong enough to resist the enormous strain caused by firing large charges with heavy projectiles [GUN], and the impossibility of using very large shot or shell made of lead alone. SMALL ARMS will be treated separately; we here speak only of rifled cannon.

The conditions which a rifled cannon should fulfil are: (1) to insure accuracy of fire; (2) to give as high velocity as possible; (3) to remain uninjured by much work; (4) to be simple in construction. To insure accuracy of fire, a rotatory motion must be given to the projectile round an axis coincident with that of the bore; the axis of the shot must be stable on leaving the piece; and the shot must have sufficient velocity of rotation (depending on its form, length, and weight) to counteract the tendency which it has to turn over. To give the projectile a high velocity, the gun must be able to stand a large charge of powder; and in order to do this, remaining uninjured, a very strong construction is required. This strength will depend on the quality of the metal used, on its being distributed so as best to resist the strains to which the different parts are subjected, and on the method of rifling not exerting undue strain on the gun. The construction should be so simple that the gun may be easily and rapidly worked, and not liable to derangement.

Breech-loading and muzzle-loading rifled ordnance have each their advocates. The advantages of the former are that a projectile of larger diameter than the bore can be used, and so its axis will be perfectly stable; that the gun can be loaded when run up (the gunners being thus less exposed), and can be worked in a smaller space; that the bore can be easily examined and cleaned; and that a shot is sure to be *home*. Their disadvantages, as compared with muzzle-loading guns, are that the construction is necessarily more complicated; with large guns the breech-loading apparatus is heavy; and they are weaker, weight for weight.

As soon as it appeared that rifled guns would be generally substituted for smooth-bored guns, numerous schemes were brought forward, which may for all practical purposes be classed under one of the four following heads:—

1. Muzzle or breech-loading guns having projectiles of hard metal fitting the bore mechanically.
2. Muzzle-loading guns with projectiles having soft metal studs or ribs to fit the grooves.
3. Muzzle-loading guns with projectiles having soft metal envelopes or cups to be expanded in the bore by the gas.
4. Breech-loading guns, with projectiles coated with soft metal, larger in diameter than the bore, but compressed by the gas into the grooves.

We will first consider some of the most important English systems of rifling. As examples of the first class, in which the projectiles are of hard metal, and made to fit the bore mechanically, we may notice the Whitworth and Lancaster guns. The Whitworth gun has an hexagonal spiral bore, with the corners rounded off. The form of bore and projectile are shown in fig. 4. The Lancaster gun has an elliptical spiral bore (fig. 5). Although it may be scarcely correct to speak of these forms of bore as grooved, it will be seen that a circle, by having in the one case six, and in the other two grooves cut, and the corners chamfered away, can be altered into either of these shapes. In both cases the projectiles are of iron or steel.

Fig. 4.

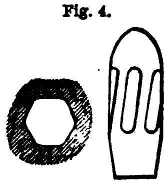
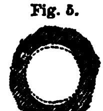


Fig. 5.

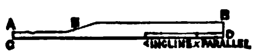


In these systems it is evident that the projectile cannot fit the bore perfectly, and that

there must be some allowance of windage. If this is reduced too much, there will be great difficulty in loading, and a small quantity of rust or dirt on either bore or shot will render the gun temporarily unserviceable; if, on the other hand, there be too much windage, the shot will not be stable on leaving the bore. Besides this there must be a great tendency to wear out the gun, by the action of the hard metal of the projectile upon it.

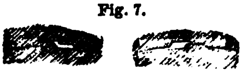
It is evident that the chief difficulty with a muzzle-loading rifled gun is to load easily, and yet insure stability of axis of the projectile on leaving the bore. This is ingeniously overcome in the Armstrong shunt gun, which, with the Woolwich system and Scott's, belongs to the second class. A shot in entering a gun with spiral grooves, presses or bears against one side of the grooves; in coming out, against the other side. In the shunt gun the stud for the shot is only about half the width of the groove. The half of the groove on which the shot enters is of uniform depth throughout, and allows some windage; but the half of the groove on which the shot bears in coming out is gradually decreased in depth towards the muzzle by an inclined plane, so that the shot is firmly gripped before it reaches the muzzle, and leaves the bore with a stable axis. A plan of a groove of the shunt gun, and plans of the muzzle, are

Fig. 6.



shown in figs. 6 and 7. The shot is shown going in and coming out. In going in, the shot

Fig. 7.



Shot going in. Shot coming out.

at E is *shunted* into the narrow portion of the groove. The studs for the projectiles of this gun are of copper. Scott's gun has a bore shaped as in fig. 8; the driving side of the studs on the projectile are of zinc, and they enter at the deep portion of the grooves, bearing on the shallow portions as they come out. The Woolwich system is only a slight modification of the French, which will be spoken of presently, the grooves being shallower, and having their corners rounded off. The large muzzle-loading guns in our service are rifled on this system, some having a uniform, and others a gaining twist. In the latter case the studs in the front row are smaller in diameter than those in the hind row, the sides of the studs which bear in loading having no spiral; but the sides which bear coming out having a spiral corresponding to the sharpest twist of the rifling, which is of course next the muzzle (fig. 9). By this arrangement the shot is driven by the hind studs only, until near the muzzle, when both studs act, and the shot is brought into the proper position on leaving the piece.

Fig. 8.

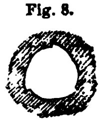
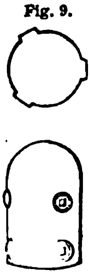
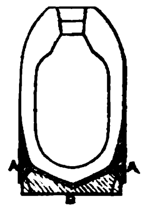


Fig. 9.



The third class includes the American Parrott gun, Blakely's, Jeffrey's, Lynall Thomas', Bashley Britten's guns. The latter, which may be taken as a good sample of this class, has five shallow grooves; and the projectile, which is made of iron, has a leaden envelope A, and a wooden sabot B (fig. 10). The shell is easily inserted, being smaller than the bore; but when the gun is fired, the sabot is driven against the envelope, and expands the lead into the grooves. Projectiles of this nature will not generally stand large charges, the envelope giving way.

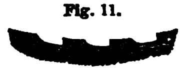
Fig. 10.



Mackay's system is also really of this class. The gun is grooved, and the projectile, which is of iron, is smaller in diameter than the bore. It has neither envelope nor studs, but a large cartridge of sawdust is inserted between the powder and the shot, and is doubtless compressed on the discharge, and jammed between the shot and the bore, thus entering the grooves, and giving rotation to the shot.

The fourth class includes the Prussian gun, and the Armstrong breech-loading guns. The latter have been adopted into our service for all rifled field guns, and several larger natures. The projectile is coated with lead, and is inserted into a chamber behind the bore, of larger diameter than the bore (fig. 13). The bore has a number of small grooves, separated by *lands*, narrower than the grooves (fig. 11). The explosion drives the projectile into the bore, compressing its soft coating into the grooves, and so giving a rotatory motion to the shot. There are two methods of closing the breech; the first by a vent piece, which is dropped into a slot, and pressed tightly against the rear of the powder chamber by a screw; the second by a wedge and stopper, which work in guiding grooves, and are forced in sideways behind the powder chamber.

Fig. 11.



But the peculiar *system* of rifling, or method of giving the rotation, matters but little, so long as the conditions above named are fulfilled; if projectiles of the same form, size, and weight, be fired with equal charges from various guns, having the same *twist*, the results will vary but little, no matter what may be the system of rifling. The great problem to solve is how to construct a gun of sufficient strength to withstand heavy projectiles fired with large charges.

When a charge of powder is ignited in the bore of a gun, the gas exerts a pressure equal in every direction, which forces the shot through the grooves along the bore, and exerts a double strain upon the metal of the gun, a *tangential strain* tending to rend the metal lengthwise

along a line drawn from breech to muzzle, and a *longitudinal strain* tending to fracture the gun across, or to drive out the breech. The *initial strain*, or the strain to which the gun is subjected before the shot moves, is the most severe, for the gas, being then confined in the smallest space, exerts its maximum pressure per square inch; and this *initial strain* generally fractures a gun. Now, the longer it takes to move the shot, the more powder will be ignited before the shot's motion, and the greater will be the initial strain. In a smooth-bored gun the shot is rolled along the surface of the bore, probably when only a very small portion of powder is converted into gas. In a rifled gun there is considerable friction between the elongated shot and the bore, additional work is required to give the shot a rotatory motion, and the area of projectile presented to the force of the gas is much less for a given weight of shot, than with a round shot. Besides, in those systems which have soft coatings or envelopes for the projectiles, additional work is required to compress the soft metal into the grooves. Thus there is much greater difficulty in moving the shot in a rifled gun, and consequently also a much greater strain than on the metal of a smooth-bored gun.

Bronze and cast iron, the metals chiefly employed as materials for ordnance until the introduction of rifled guns, are not suited to withstand this great strain. Bronze, though tough, and, if well made, uniform in quality, is too soft for the bores of guns, and is also very costly; cast iron, although hard enough, is uncertain in tenacity, and cannot alone be used for rifled guns, unless fired with very small charges only. Cast-iron guns strengthened by rings or tubes shrunk or driven on externally, will not stand great strain, but moderately good results have been obtained by lining them with a tube of wrought iron or steel, as proposed by Major Palliser.

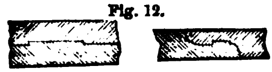
Wrought iron and steel are the metals now almost universally employed for rifled guns. Wrought iron is exceedingly tough, and not liable to snap or to fly into destructive pieces, but it is rather too soft for the bore of a gun, and it is very difficult to obtain thoroughly sound forgings of great size. Cast steel, well hammered, is hard and elastic, but is liable to snap without warning and fly into pieces; it is rendered harder and tougher by being tempered in oil, but there is great difficulty in obtaining large castings of thoroughly uniform quality. Steel is also very expensive.

It has not as yet been found practicable in this country to make large rifled guns in one solid casting of great strength; though in Krupp's works, at Essen, in Prussia, large guns are so made. Even their endurance, however, is not such as would satisfy us in this country. The formation of guns from one solid forging has been advocated, but condemned by many good authorities. The Horsfall smooth-bored gun, made at the Mersey Works at Liverpool, was of this nature. It weighed nearly twenty-five tons, and had a calibre of 13 inches.

The method chiefly employed in this country is to build up guns of several pieces. By this plan several advantages are gained. 1. The parts may be of such a size that their soundness may be depended upon. 2. Different* materials may be used, each being placed at that part of a gun which it best suits. 3. The materials may be applied so that their fibres may run in a direction most favourable to the peculiar strain they will have to withstand. But in this method of construction, great care must be taken to provide against the separation of the parts; and it is evident that the fewer parts there are, the less likely will the gun be to shake to pieces. Whitworth advocates steel for all parts of a gun. His method of building up, as given in his own words, is this: 'The tube of the gun is made taper, then a series of hoops are made, which are screwed on together so as to form another tube, that is put on by hydraulic pressure; each layer is put on a little tighter than the succeeding one.' Blakely is also a strong advocate of steel for all parts of a gun, though he has employed both cast and wrought iron. His method of shrinking on the outer tubes when hot, so that in cooling they contract and grasp the inner tubes, is employed in the manufacture of Armstrong guns, and in the gun factories at Woolwich.

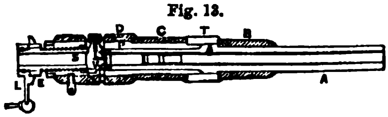
The essential features of the Armstrong method of construction are: 1. The disposal of the fibre of the metal round the bore, by coiling, so as to resist the tangential strain, the welds running in the direction of the least strain as regards separation. 2. The employment of a breech piece to support the bottom of the bore, with the fibre running lengthwise so as to resist longitudinal strain. 3. The shrinking on the different portions, so that the exterior of the gun takes a due share of strain. The different parts of the gun are also now hooked together by means of

Fig. 12.



shoulders and corresponding recesses. Both coiled iron barrels and steel barrels are now used in the royal gun factories, with forged breech pieces and trunnion pieces, and coiled outer tubes. Fig. 13 represents a section of an Armstrong 12-pr. screw breech-loading gun.

Fig. 13.



A A, barrel, coiled iron or steel.
B C D, coiled outer tubes.
P, breech piece, solid forging.
T, trunnion ring, ditto.
V, vent piece.
E, tappet ring.
L, lever ring.
S, breech screw.

The same method of construction, with modifications, has been adopted for our larger guns. Mr. Fraser, of the royal gun factories, has suggested some important improvements, which will both strengthen the gun and lessen its cost.

The principal methods of construction and systems of rifling of this country having now been explained, it remains briefly to mention the rifled guns of the principal foreign nations.

The French have adopted the *système la Hitte*, the shape of the groove and stud in which are shown in the annexed figure. The studs are of zinc, and centre the projectile by means of bevelled driving edges. The French field guns are of bronze; the *canon de 4 rayé*, which is their general service field gun, has the same calibre as the old brass 4-pounder; it has six deep grooves, and the projectile has two rows of studs. Their heavy guns are principally cast iron hooped with steel, and muzzle loaders, with a gaining twist applied to the system above described. They have a few breech loaders, up to, but not over, six inches calibre.

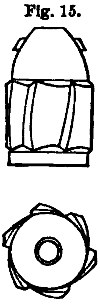
Fig. 14.

The French system has been adopted, with modifications, by Spain, Portugal, Russia, Holland, Switzerland, Würtemburg, and, as already shown, by ourselves for some guns.

The Italians have chosen the French system for their field guns, which are made of bronze up to the 16-pounder; they have some 24-pounder and 40-pounder iron-hooped guns, muzzle-loaders, and a few heavy breech-loading cast-iron Cavalli guns, which were cast in England, and proved at Woolwich.

The Austrian field guns are bronze muzzle-loaders, and the projectiles are covered with zinc and tin (fig. 15) of the same shape as the bore, but one-twelfth of an inch less in diameter. The grooves in the gun may be said to be formed by wrapping a number of triangles round a cylindrical bore. The exterior of the projectile being of the same shape, the latter enters the bore easily and is pushed home, riding on the bases of the triangles, with windage above and at the sides. A slight turn with the rammer, acting on small drivers left on the head of the shell, centres it, so that it comes out with its axis coincident with that of the bore, and windage equally distributed, viz. a small space at the base of each of the triangles. The projectile for what is called the 4-pounder field gun weighs about 8 lbs. English, and the gun itself about 582 lbs. The Austrians have lately made a number of breech-loading cast-iron guns for siege and garrison purposes, on the old Prussian system, the *Kolben verschluss* of Wahrendorff. A cylinder, introduced through a hole at the side of the breech, fits into a corresponding orifice in the breech stopper, thus preventing the latter from being driven back; but this cylinder frequently becomes jammed, and the action of the arrangement cannot therefore be considered successful. They have also bought some of Krupp's guns, rifled and with his patent breech-loading arrangement. At one time they introduced several batteries of rifled guns for gun cotton, but in the autumn of 1862 these were abandoned, and the present system introduced. The *système la Hitte* had been previously tried and condemned.

Fig. 15.



The Prussians have a few 24-pounder bronze breech-loaders on their new system (Krainer's), throwing shell weighing about 60 English pounds; and some 6-pounders and 12-pounders throwing projectiles of 15 lbs. and 32 lbs. respectively. For field guns they have entirely adopted the breech-loading system and steel guns. The latter are cast and hammered by Krupp, of Essen, and afterwards bored and rifled at Spandau near Berlin. The 4-pounder is the field gun of the Prussian service, the projectile weighing about 9½ lbs. English. The breech is closed by a double wedge which works at the side, as in our own wedge system. Into the face of the front wedge fits a loose steel cup to take the first shock of the discharge, and to contain a copper ring valve, so arranged as to be pressed closer to the back of the bore by the gas. This can be taken out and cleaned, or replaced by another almost instantaneously.

Krupp's system, which is both simple and strong, has been partially adopted by many powers. The breech is closed by a single thick steel wedge, which slides in and out easily, and is driven firmly home, after it has been pushed in, by a lever and screw, the latter working half in the breech and half in the gun. The recess in the wedge corresponding to the steel cup in the Prussian system contains a copper ring valve like that in the Prussian system. In both these systems (Krainer's and Krupp's) the gun is multigrooved, and the projectile has a soft metal coating with three raised rings of the same material.

The Russians, in addition to guns on the modified French system, have bought the heaviest Krupp's guns yet made, of 11 inches calibre, about 540-pounders, for Cronstadt. They have also several American guns, a few shunt guns, and some Blakely guns. A committee held in 1865, of which General Todleben was president, has decided that steel 8·58 calibre breech-loading guns are to be adopted for coast defences; that they are accurate, good against armour plate, and stand 425 rounds at least; but that Krupp's muzzle-loading guns of large calibre cannot be considered safe after 250 rounds have been fired from them. Broadwell's system of breech-loading, a modification of Krupp's, will probably be definitely adopted.

The Turks are arming their ships principally with Armstrong's guns.

The Japanese have purchased fifty of Krupp's six-inch guns.

The Swedes have tried Wahrendorff's breech-loading system, but both they and the Danes are settling down to the definite adoption of muzzle-loaders on a modification of the shunt system. All their ordnance are cast iron, but some pieces will be strengthened by internal steel tubes.

The Americans have a great variety of pieces; their navy still favours cast-iron smooth-bored guns of large calibre. Some twenty-inch guns have been made, a pair of which are fitted to the 'Puritan' ironclad, a park of them being also in readiness for land service; but these will only stand comparatively small charges, although by a method of cooling from the interior, invented by Rodman, greater strength is obtained in the cast iron of which they are made. Their rifled Parrott guns, which are made of cast iron strengthened with wrought-iron hoops, were of much service during the war, though several cases of bursting occurred. A committee on ordnance has recommended the Ames gun, which is built up of wrought iron. No breech-loading system is in favour in America, their plan being generally, as in the Parrott gun, a ring of brass at the base of the projectile, which is expanded by the gas into the grooves; or, as in the Schenkel system, a papier-mâché detached wad, which takes the rotation, and transfers it to the projectile.

On comparing the rifled ordnance of foreign powers with that of our own country, we have no reason to be dissatisfied. Our guns, being made of wrought iron, will not, on failure, break up like cast iron or steel ordnance; and from their accuracy of fire, the capacity of their shells, and the power which the latter have, owing to their elongated form, of maintaining a high velocity, obtained from the large charges which we are able to use, they are certainly not surpassed by those of any other nation.

For further information, the reader is referred to Major Owen's *Lectures on Artillery*, 4th edition. For minute details, it is necessary to consult professional papers, bluebooks, &c.

Rig (A.-Sax. wrigan, *to dress*). The peculiar manner of fitting the masts and rigging to the hull of any vessel; thus the terms *schooner rig*, *ship rig*, &c., imply the masts and sails of these vessels without regard to the hull.

Rig Veda. [VEDA.]

Rigging. On Shipboard, the system of cordage by which the masts are supported, and the sails extended or taken in. The rigging is hence divided into *standing rigging* and *running rigging*. The standing rigging consists of the *pendants*, short strong ropes first put over the lower mast heads, and having thimbles for hooking tackles to; the *shrouds*, *stays*, and *backstays*. The lower rigging implies that of the lower masts, the topmast rigging that of the topmast, and so on. The running rigging comprises the lifts for raising and lowering the upper masts and the yards, the braces for trimming the yards, the halyards for hoisting flags, &c., and the clew-lines, sheets, tacks, and guys used in managing the sails. The size, strength, number of ropes &c. of the rigging, are all matters determined by experience.

Rigging Loft. The room or rooms in which the rigging is prepared and tested.

Right (Ger. recht, akin to Lat. rectus). In Geometry, a term applied to certain figures which are deemed to be the simplest of their kind. Thus a *right line* is one whose direction never varies; the more common term is *straight*. A *right angle*, again, is formed by two straight lines which intersect each other in the most symmetrical manner; i.e. in such a way as to divide the whole angular space around their point of intersection into four equal parts. Similarly, a *right prism* is one whose edges are perpendicular to the plane of its base, whilst in a *right cylinder* and *right cone* the base is a circle whose plane is perpendicular to the axis of symmetry. In these cases, as in many others, the term *right* is opposed to *oblique*.

Right Ascension. In Astronomy, the angle formed at the pole of the equator by two great circles, one of which passes through the first point of Aries, and the other through a celestial body; it is consequently measured by the arc of the equator intercepted between those circles. *Right ascension* and *declination* are the two coordinates to which the positions of celestial objects are for the most part referred. It is sometimes convenient, however, to give their latitudes and longitudes.

Right, Divine. [DIVINE RIGHT OF KINGS.]

Right, Petition of. A declaratory enactment passed by the parliament of 1628. This name was adopted by the framers, who wished to imply by it that the franchises therein specified were not newly acquired, and that the law was merely explanatory of the ancient constitution. It was calculated to protect the subject against forced loans, benevolences, taxes imposed without consent of parliament, arbitrary imprisonments, &c. Much delay and some evasion took place before Charles I. could be induced to give the royal assent to this measure.

RIGHT, PETITION OF. This term also denotes the process by which a subject may obtain possession or restitution from the crown of either real or personal property. The proceedings upon it have recently been simplified (23 & 24 Vict. c. 34), and assimilated in many respects to the course of an ordinary action between subject and subject.

Rights, Bill of. [BILL OF RIGHTS.]

Rigidity (Lat. rigiditas). In Mechanics, a resistance to change of form. In theoretical investigations respecting the application of forces through the intervention of machines, the latter are frequently assumed to be perfectly rigid, so far as the forces employed are able to affect their integrity of form and structure. Rigidity is often, in the arts, called *stiffness*, and is opposed to flexibility.

Rigor Mortis (Lat.). In Physiology, the general stiffening of the body produced by the simultaneous contraction of all the muscles of the trunk after death. The muscular coat of the arteries also contracts after death, on division and mechanical irritation, on the application of cold, and under the stimulus of electricity.

Rilievo. [RELIEF.]

Rimose (Lat. rimosus, from rima, *a fissure*). In Zoology, when the surface of an animal or part resembles the bark of a tree, having numerous minute, narrow, and nearly parallel excavations which run into each other.

Rinderpest or **Cattle Plague.** The Report of the Cattle Plague Commission (May 1866) renders it necessary to make a few remarks in addition to those already made in the article MURRAIN. Although no unfailing specific has been discovered, some facts have been ascertained which throw considerable light on the pathology of this disorder. It appears that within forty-eight hours of the time when the animal has imbibed the disease, the temperature of the body rises from two to three and a half degrees of the thermometer. The period of incubation is thus shown to be shorter than was generally supposed, and this rise of temperature is especially valuable as furnishing a means of separating sick from healthy cattle, and shortening the time of quarantine. The whole course of the disease is seven days; but hitherto it has been erroneously treated as beginning when it has already existed for four days, and obtained a fatal hold on its victim. It is confined almost entirely to ruminating animals, although it may exist in the sheep and goat. The commissioners unanimously report that it is propagated only by contagion, and that it consists in a poison generated in the blood and capable of being conveyed by inoculation, the increase of the poisonous matter when the disease is once established being marvellously rapid. For the purpose of disinfection they recommend chlorine and the acids obtained from tar and sulphur. Inoculation and vaccination with the matter of the cow-pox have been tried as a preventive without success. All strong medicines, it is asserted, heighten the mortality; and the only remedies suggested are cleanliness, ventilation, disinfection, and careful feeding. If these conclusions accord with the facts, the necessity of a strict quarantine becomes imperative for all cattle arriving from foreign ports.

In their third and final report, issued June 1866, the commissioners adhere to their former conclusions as supported by microscopic and other experiments. Having used the highest magnifying powers, Dr. Beale considers that 'with regard to the nature of the contagion itself, evidence has been adduced to show that it consists of very minute particles of matter in a living state, each capable of growing and multiplying rapidly when placed under favourable conditions; that the rate of growth and multiplication of these minute particles far exceeds that at which the normal germinal matter of the blood and tissues multiplies, and that they appropriate the pabulum of the tissues, and even grow at their expense.'

The most efficient disinfecting agents, sulphurous and carbolic acids, are supposed to act by destroying the vitality of the poisonous particles emanating from animals in a state of disease. On the whole, the commissioners are convinced of the necessity of treating the disease as strictly contagious, and of the importance of marking the rise of the natural temperature of the animal as the first and surest symptom that the disorder has begun.

Rinforzando (Ital. *strengthening*). In Music, a direction to the performer, denoting that the sound is to be increased. It is marked thus < ; and is also expressed by the abbreviation *rf.*

Ring (A.-Sax. hring). A solid body generated by a circle whose centre describes a closed curve to which the plane of the circle is always normal. The radius of the generating circle is usually constant, so that the ring is enclosed by a TUBULAR SURFACE. Ordinarily, too, the locus of the centre of the generating circle is itself a circle. [ANNULUS.]

Ring of an Anchor. The ring, bolted into the top of the shaft, to which the cable is made fast.

Ring Bone. In Farriery, a callus growing in the hollow circle of the little pastern of a horse, just above the coronet.

Ring Sail. A small and light sail set on a mast on the taffrail. Also a studding sail set upon the gaff of a fore-and-aft sail, and stretched on the ring-tail-boom. It is very rarely used.

Ring of Saturn. [SATURN.]

Rings, Fairy. [FAIRY RINGS.]

Rings, Meteoric. [METEORS, LUMINOUS.]

Ring-bolt. On Shipboard, a strong iron ring passing through a hole at the end of an iron pin, which is clinched through the beams of the deck or the side. The principal use is to give bearing to the tackle for running the guns in and out.

Ring-ropes. Auxiliary ropes bearing on ring-bolts in the deck, and temporarily fastened to the cable at different parts in very heavy weather, to furnish a more powerful hold on it while diminishing the strain on the riding bitts.

Ringworm. This disease is of two kinds, viz. the ringworm of the body and the ringworm of the scalp. The former is a vesicular eruption (*Herpes circinatus*), and is not contagious; while the latter is a pustular form of disease (*Porrigo scutulata*), and so contagious as to prove a scourge to any public establishment into which it may be introduced. The ringworm of the body is by no means a very manageable disease: it is to be treated by attending to the general health, and by applying astringent mineral lotions. The ringworm of the scalp is a most obstinate affection. It begins with clusters of little pustules, which form scabs, leaving a red pimply surface, and destroying the roots of the hair as the disease proceeds

(which it never fails to do if not prevented) over the greater part of the head. It is most common in children of a feeble flabby habit; but as it is communicable by contagion, it spreads rapidly in schools and families by the frequent contact of the heads of children, or by the use of the same caps, combs, towels, &c.: so that when it once appears, the diseased children should be strictly removed from the others. The treatment consists in shaving the head, and using frequent and regular ablutions in the first instance, sponging the part with weak soap-and-water; when the scabbing begins, other applications must be used, the selection of which must entirely depend upon the degree of irritation and other circumstances. Solutions of nitrate of silver, sulphate of copper, iodide of potassium, or of iron, pitch and tar ointments, petroleum and naphtha, mercurial ointments of different kinds, various other stimulants, as also sometimes sedatives, are resorted to, to get rid of the morbid state of the part; but so whimsical and obstinate is the disease, that it is impossible to lay down any mode of treatment which can be considered as approaching to a specific. Except in particular cases, no internal medicine has appeared to be of use.

Riolite. A native selenide of silver found at Tasco in Mexico, and named after Del Rio, by whom it was analysed.

Riot (Ital. riotta). In Law, a tumultuous disturbance of the peace by three persons or more assembling together of their own authority in order to assist each other, against anyone who shall oppose them, in the execution of a private purpose, and afterwards executing the same in a violent and turbulent manner. A *rout* is said to be a disturbance of the peace by persons assembled together to do a thing, which, if executed, would make them rioters, and making some motion towards that object: an *unlawful assembly* is a similar disturbance by persons who neither execute their purpose, nor make any actual motion towards the execution of it.

Ripidolite (Gr. ῥιπίς, *a fan*, and λίθος, *stone*). The name given by Von Kobell to a green Chlorite occurring in grouped folia, at St. Gotthard, at Rauris in Salzburg, and in the Zillerthal. It is a hydrated silicate of alumina, protoxide of iron and magnesia, and is found at Penrhyn in Caernarvonshire, and in Argyleshire; also in Dauphiny, the Ural, the Harz, the Alps, and at Gumush-dagh in Asia Minor.

Ripieno (Ital.). In Music, a term signifying *full*, and used in compositions of many parts, to distinguish those which fill up the harmony and play only occasionally, from those that play throughout the piece.

Ripple Marks. The peculiar undulated marks, left by the receding waves on the sea beach, which are occasionally found in some of the older strata of rocks, and are considered as announcing a similar action at a remote period. The wind blowing over a sandy district sometimes occasions a similar appearance.

Rishis, The Seven. In Sanscrit Mythology, the seven sages who were supposed to dwell in the seven stars of the constellation known by us as the Great Bear. This notion belongs to that large class of legends which spring up from the partial or total forgetfulness of the original meaning of a word. Such misapprehensions, it is obvious, must arise when families and tribes diverge from a common centre, carrying with them a number of words expressive of sensible or material notions. Such words would assume more and more the character of personal appellatives, the extent of the change being determined by the measure in which the original force of the word was remembered. Thus such names as Endymion and Anadyomene are even in later legends little more than epithets; but the Greek Argynnis became a maiden beloved by Agamemnon, whereas the Sanscrit *arjunî* remains a simple epithet denoting beauty. But when such words had sunk into mere proper names, they were liable, by a process common to all languages, to be confounded with other words which they might happen most nearly to resemble in sound. The result would be, in grammatical phrase, false etymology; the practical consequence would be the growth of a myth. From a root which meant to shine, the Seven Ṛikshas, or shiners, received their name; and to the same root probably belongs the name of the golden bear, the Greek ἄρκτος, and Latin ursa, as the Germans gave to the lion the title of goldfusz; and thus when the epithet had by some tribes been confined to the bear, the seven shiners were transformed into seven bears, then into one bear with Arcturus for their bearward. In India also the meaning of ṛiksha was forgotten; but instead of referring the word to bears, the people confounded it with rishi, *wise*, and the seven stars or shiners became the abode of seven sages or poets. The same lot befel another name for this constellation. They who spoke of the seven *triones* had long forgotten that their fathers spoke of the stars as *târâs* (staras), or strewers of light, and converted the bearward into Boötes, the ploughman; while the Teutonic nations, unconscious that they had retained the old root in their word *stern* or *star*, likewise embodied a false etymology in wagons and wains. (Max Müller, *Lectures on Language*, second series, viii.; *Westminster Review*, January 1865, p. 48.)

Rising Line. On the sheer-plan and other draughts of a ship, a curved line marking the height of the floor timbers throughout the length, and thereby fixing the sharpness and flatness of the vessel's bottom.

Rising Wood. In Shipbuilding, the portion of the keel let into the floors.

Risus Sardonicus (Lat. *the sardonic laugh*). A convulsive grin, giving a peculiarly horrible expression to the countenance, chiefly

observed in cases of tetanus and inflammation of the diaphragm. It has been generally supposed to have been so named, as being produced by eating a species of ranunculus growing about certain springs in Sardinia; but this derivation is far from probable, and the Greek phrase *σαρδάνιον γελᾶν* indicates merely a grim, bitter laugh, and points to the verb *σαίρω*, to grin or sneer.

Ritornello (Ital. *a return*). In Music, properly a short repetition, such as that of an echo, or of the last words of a song, especially if such repetition be made after a voice by one or more instruments. But by custom this word is now used to denote all symphonies played to a song before the voice begins or after it ends.

Rittingerite. A mineral found at Joachimstahl in Bohemia, and named after Rittinger, an Austrian officer of mines. It is a sulphide of silver and antimony.

Ritual (Lat. ritualis, from ritus, *a rite*). A book in which the different rites or services of the church are contained.

River Systems. So far as rivers depend for their water supplies on the rain falling on the land through which they run, it is clear that each river, whether entering the ocean, or terminating in an inland sea or lake, or losing itself in a sand desert, may be regarded as including the natural surface drainage of the whole tract of land through which runs every branch of the river and all its tributaries, whether large or small. Thus the greater part of a continent may be grouped into a few districts, each designated by the principal rivers running through it. Every such district is called in physical geography a *river basin*; and the whole group of streams having one outlet is denominated a *river system*. Those which connect with the ocean are called *oceanic*; and those not reaching the ocean, *continental*. The line separating two such districts is the line of *watershed*, from the German *wasserscheide* (water-parting).

The principal river systems of the world are named in the subjoined table, and the details of the more important will be found referred to in separate paragraphs.

	Drainage Area	Length of Course	
		Direct	With Windings
Atlantic Group.			
EUROPEAN COAST:—	sq. m.		
Rhine	87,000	410	700
Elbe	56,000	400	780
Loire	45,250	375	600
Douro	40,000	300	500
Garonne	32,500	225	370
Seine	30,000	250	400
Tagus	29,000	410	550
Guadiana	26,000	275	480
Guadalquivir	20,000	205	300
Weser	17,500	230	320
Minho	15,750	125	220
Thames	6,500	130	220
Atlantic Group.			
BALTIC SEA:—	sq. m.		
Neva	89,500	360	500
Vistula	75,500	320	600
Oder	52,000	320	550
Dwina	44,500	320	650
Niemen	43,250	275	530
MEDITERRANEAN SEA:—			
Po	40,000	260	400
Rhone	37,000	285	640
Ebro	33,000	310	480
Nile	1,000,000?	2600?	3000?
EUXINE OR BLACK SEA:—			
Danube	310,000	1000	1750
Dnieper	226,000	630	1250
Don	224,500	460	1150
Dniester	30,000	410	520
AFRICAN COAST:—			
Niger, Senegal, Orange River, &c.	1,000,000?		
NORTH AMERICAN COAST:—			
St. Lawrence and lakes	402,000	975	2050
Connecticut	11,000	265	300
Delaware	12,000	205	300
MEXICAN GULF:—			
Mississippi	1,300,000	1600	4000
Rio del Norte	250,000	1400	2000
Magdalena	95,000	640	1000
SOUTH AMERICAN COAST:—			
Amazons	2,000,000	1780	?
Plata	1,175,000	1180	2200
Tocantins	380,000	1150	1300
Orinoco	335,000	425	1550
St. Francisco	250,000	1000	1600
Paranahyba	153,000	640	860
Essequibo	82,000	400	490
Pacific Group.			
EASTERN ASIA:—			
Amour	777,000	1400	2750
Tang-tse-kiang	727,000	1750	3300
Hoang-ho	716,500	1325	2650
Tche-kiang	133,000	575	1200
AMERICA:—			
Frazer River	?	620	?
Columbia	260,000	670	1540
Colorado	225,000	580	920
Indian Ocean Group.			
Ganges and Bramahpootra	576,500	950	2000
Irawadi	440,000	1250	2500
Indus	415,000	1030	2300
Menam	288,000	700	1100
Euphrates	260,000	680	1720
Godavery	124,000	620	850
Kistna	110,000	500	800
Zambesi (Africa)	250,000	1200?	?
Arctic Group.			
ASIA:—			
Obi	1,233,000	1475	2650
Yenesei	1,050,000	1400	3200
Lena	800,000	1400	2750
Kolyma	150,000	515	950
Dwina	140,000	460	1000
AMERICA:—			
Mackenzie	600,000	1100	2400
Saskatchewan	480,000	765	1030
Churchill	100,000	1050	1900
Albany	70,000	440	640

	Drainage Area	Length of Course	
		Direct	With Windings
Continental Systems of Asia.			
CASPIAN :—	sq. m.		
Volga	530,000	1020	2750
Oural	110,000	630	?
ARAL :—			
Sir	320,000	680	1350
Amo	260,000	920	1600
LOB LAKE :—			
Rivers (sundry) . .	240,000	685	1260

River Walls. Works executed to defend the shores of rivers are commonly known as river walls, whether they are walls in strictness of speech, or only an inclined fore shore with a paved slope towards the river. Examples of the latter kinds may be seen on the banks of the Thames, the Severn, the Seine, the Orne, the Rhine, the Rhone, &c. But in the midst of the great centres of population it becomes necessary to economise space, and *walls* are used, more or less inclined to the water, of which a good example is to be found in the Thames embankment. The principles on which these are founded are that a sufficient space should be left for the water-way, so as not to produce any scour likely to injure the bank, and to insure the resistance of the materials employed in the composition of the walls. [SEA AND RIVER DEFENCES.]

Rivers (Lat. rivus, the root being found in Sansc. sru, Gr. *ῥέω, to flow*). In Physical Geography, an inland current of water, formed within a certain portion of the earth's surface by the confluence of brooks, small streams, or mountain torrents, and discharging itself into the ocean, a lake, a marsh, or another river. There are few subjects in physical geography which present so wide a field for speculation as rivers, whether we regard them in an historical, political, economical, or scientific point of view. They are associated with the earliest efforts of mankind to emerge from a state of barbarism; but they are no less serviceable to nations which have advanced in civilisation. In the earliest ages they were regarded with veneration, and became the objects of a grateful adoration, surpassed only by that paid to the sun and the host of heaven. Nor is this surprising; for in countries where the labours of the husbandman and shepherd depended for a successful issue on the falling of periodical rains, or the melting of the collected snows in a far-distant country, such rivers as the Nile, the Ganges, and the Indus were the visible agents of nature in bestowing on the inhabitants of their banks all the blessings of a rich and spontaneous fertility; and hence their waters were held sacred, and they received, and to this day retain, the adoration of the people through whose land they flow. But it is by countries which have already made progress in civilisation (to which, indeed, they largely contribute) that the advantages of rivers are best appreciated, in their adaptation to the purposes of navigation, and in their application to the useful arts. Like the veins and arteries of the human body, which convey life and strength to its remotest extremities, rivers vivify, maintain, and excite the efforts of human industry; whether we regard them near their source as the humble instruments of turning a mill, or in their progress as facilitating the transport of agricultural or manufacturing produce from one district to another, or as enriching the countries at their mouths with the varied products of distant lands. This has been admirably expressed by Pliny. 'The beginnings of a river,' he says, 'are insignificant, and its infancy is frivolous: it plays among the flowers of a meadow; it waters a garden, or turns a little mill. Gathering strength, in its youth it becomes wild and impetuous. Impatient of the restraints which it still meets with in the hollows among the mountains, it is restless and fretful; quick in its turning, and unsteady in its course. Now it is a roaring cataract, tearing up and overturning whatever opposes its progress, and it shoots headlong down from a rock; then it becomes a sullen and gloomy pool, buried in the bottom of a glen. Recovering breath by repose, it again dashes along, till, tired of uproar and mischief, it quits all that it has swept along, and leaves the opening of the valley strewed with the rejected waste. Now quitting its retirement, it comes abroad into the world, journeying with more prudence and discretion through cultivated fields, yielding to circumstances, and winding round that which it would be troublesome to overwhelm or remove. It passes through the populous cities, and all the busy haunts of man, tendering its services on every side, and becomes the support and ornament of the country. Increased by numerous alliances, and advanced in its course, it becomes grave and stately in its motions, loves peace and quiet, and in majestic silence rolls on its mighty waters till it is laid to rest in the vast abyss.'

Many large rivers have their origin in elevated mountains, or on high table-lands, the height and direction of which chiefly determine their size and course. For information on some of the points involved in this subject, we refer the reader to the article on RIVER SYSTEMS. We shall in this place confine our remarks to some of the most striking peculiarities of rivers, such as *periodical inundations, engulfment*, and *reappearance*.

The periodical inundations of rivers depend on great falls of rain in mountainous regions, or on the melting of snows in the neighbourhood of their source. The period depends on the return of these seasons in different places. Within the tropics, the rainy season occurs usually about the time when the sun passes the meridian towards the tropics; and continues until his return to the same place. The rise of the Orinoco commences in May, its inundation

begins in June, and the waters return to their channel in September; from which time they decrease until April of the succeeding year. In the Lower Mississippi, whose inundations begin in March and are at their height in June, are found those enormous rafts of driftwood (formed during the inundations), which sometimes extend for ten or twelve miles in one mass, rising and falling with the stream, yet having a luxurious vegetation on their summits. The great rivers of Asia—the Ganges, the Indus, the Tigris, and Euphrates—have also their periods of inundation, depending on the circumstances which determine the setting in of the rains on the mountains in which they originate. In the Ganges the waters begin to increase in April, and at the end of July the country, for a hundred miles along its banks, presents the appearance of a vast lake interspersed with insulated villages and woods. But of all inundations, those of the Nile are the most celebrated, nor is it possible to find anywhere among terrestrial objects a more striking instance of the stability of the laws of nature, than the periodical rise and fall of this mighty river. We know by the testimony of antiquity that the inundations of the Nile have been the same, with respect to their season and duration, for more than two thousand years. Indeed, their certainty regulates the public revenue; for when by means of nilometers it is ascertained that the waters promise an unusually prosperous season, the taxes are proportionally increased. Shortly after the commencement of June, the river begins to rise, and it attains its greatest height in August. At Cairo the greatest rise is twenty-eight feet; but in the valley of the Nile, with a mean breadth of three or four leagues, it is only four feet. It decreases gradually until the following May; and as soon as the waters are within their usual channel, the soil, moistened and enriched by the sediment deposited from the inundation, is diligently cultivated by the natives. (Pliny, *Hist. Nat.* lib. v. 9.)

The subject of *the engulfment and reappearance* of certain rivers has attracted attention in every age. In some cases the phenomenon is accounted for by the spongy nature of the soil through which such rivers flow; thus the Guadiana, one of the largest rivers in Spain, suddenly disappears in the marshes near the village of Castillo de Cerrera, and after pursuing a subterraneous course for twelve or fourteen miles bursts again into day. Limestone districts afford many specimens of this phenomenon; one of the most striking of which is the occultation of the Rhone near the gorge called the *Perte*. There are also some curious instances in Derbyshire and Yorkshire. But no country surpasses Greece in the number of its subterranean streams, the peculiarities of which are often clothed in splendid mythological fictions by her ancient bards. The waters of many valleys in the Peloponnesus have no other outlets than ζέρεθρα, or chasms, which engulf them; such are the outlets of the valleys of Tegea, Mantineia, Stymphalus, Peneius, &c. A familiarity with such phenomena, and a poetical temperament, readily led the ancient Greeks to conceive still more distant secret communications; and the imagination which peopled every grove, and animated every stream with presiding deities, could easily reconcile itself to the story of the river god Alpheius, who was said to pursue his favourite nymph Arethusa beneath the bed of the ocean from Greece to the shores of Sicily. The real cause of the apparent mystery may always be found in the rocks over or among which the stream passes.

Rivose (Lat. rivus). In Zoology, a term signifying that the surface of an animal or part is marked with furrows which do not run in a parallel direction, and are rather sinuate.

Rixdollar (a corruption of Ger. reichsthaler, *dollar of the empire*). A silver coin of different values in different countries. [MONEY.]

Roach. The curve, or arch, which is generally cut in the foot of some square sails, from one clew to the other, to keep the foot clear of stays and ropes.

ROACH (A.-Sax. hreoce). A fresh-water fish, *Cyprinus rutilus* of Linnæus; *Leuciscus rutilus* of Yarrell. It is characterised by having twelve reddish rays to the anal fin, and the ventral fins very obtuse. It is found in all the fresh waters of Europe, like its congener the dace (*Leuciscus albus*).

Road or **Roadstead.** A place of anchorage distinguished from a harbour by being at some distance from the shore. A good roadstead is one protected from the prevailing winds, and from ocean swells: an open roadstead, one without such protection. A vessel when at anchor is termed a *roader* or *roadster*, in contradistinction to another under sail.

Road Metal or **Road Material.** The stone used for paving purposes. In places where the traffic is only moderately great, and funds are not abundant, it is usual in England to make what are called macadamised roads with material collected from the adjacent fields or quarries. In the large cities, however, it is necessary to resort to the hardest and best material, often obtained at great cost from a distance.

The properties required by a good road material are these: (1) hardness with toughness; (2) inability to be chemically acted on, or decomposed, or disintegrated by weather; and (3) the preservation of a rough surface during wear. Without toughness the hardest stones become easily cracked, broken down, and worn into powder by the hoofs of horses and the wheels of carriages; if acted on by acids or weather, they are soon destroyed, and if they wear smooth they become slippery and unfit for use.

Certain kinds of granite best combine these properties, and the syenite of Guernsey is the best at present known. It is a fine-grained uniform material, very durable and always rough. Many other granites, as those of Grooby, are used with advantage, and many

granites unfit for road metal are yet very valuable for flags and kerbs. There are some varieties of quartzite sufficiently tough to serve as valuable road metal; of these, the Atherstone is highly spoken of. After granites, greenstones and other volcanic rocks come in. They are often as hard, but rarely so tough or so certain to present a rough surface, as the best syenites.

Roads (A.-Sax. rade). Pathways formed through a country, by which passengers and commodities may travel, or be transported, with more or less facility and expedition, from one place to another. Roads are of various kinds, according to the state of civilisation and wealth of the country through which they are constructed, and according to the nature and extent of the traffic to be carried on upon them—from the rude paths of an aboriginal people, carried in direct lines over the natural surface of the country, passable only by foot passengers or pack-horses, to the comparatively perfect modern road, carried on an artificial causeway, and reduced to a nearly level surface at enormous expense by means of vast excavations, extensive embankments, bridges, viaducts, tunnels, and other expedients supplied by the skill and ingenuity of the civil engineer.

Advantages of Roads.—There is no expedient which more powerfully conduces to the advancement of a people in civilisation, or to the extension of their prosperity and national wealth, than the construction of good roads, connecting the various centres of commerce and industry about which they may have collected themselves. The invention of printing, and of coined money, the adoption of a uniform system of weights and measures, would severally be ineffectual, or would produce but slender results, if the intercommunication of the men whose feelings and ideas are expressed in print, and among whom money is made to circulate, and whose commerce is stimulated by the uniform module of quantity supplied by weights and measures, were not facilitated by the means of conveyance supplied by roads. Without roads, indeed, large towns or cities could not continue to exist. The supply of population collected in such places with the various products of agriculture necessary to their physical existence, could not be maintained. Nor, on the other hand, would the rural population affording that supply be benefited by a return, in exchange, of the refinements of the town, and the various articles of luxury and necessity obtained by commerce from every part of the globe.

But roads are not less necessary for the advancement of agriculture itself, than for the due maintenance of the necessary relations between the towns and the country. Without the aid of roads, it would be impossible to apply those arts to the soil by which increased powers of production are given to it. Without roads, the various kinds of manure, by which the scientific farmer knows how to raise augmented crops, could not be transported to his fields from the place, often distant and difficult of access, where such manures are found. Roads may then, in fact, be considered as a system of veins and arteries, by which all the principles necessary for the maintenance of the prosperity of a country are kept in circulation.

History of Roads.—The importance of roads to the welfare of nations was not unknown to the ancients. The senate of Athens, the government of the Lacedemonians, the Thebans, and other states of Greece, bestowed much care upon them; but, as might naturally be expected, the first great advances in the art of intercommunication by roads were due to a people essentially commercial. The invention of paved roads is traced to the Carthaginians. Rome, ever awake to the advantages to be gained from conquered people, followed in the steps of the Carthaginians, and vastly extended and improved their processes in the construction of roads.

The Via Appia, the Via Aurelia, and the Via Flaminia were the first great monuments of the Roman people in this department of art. Under Julius Cæsar, the capital of the empire was made to communicate with all the chief towns by paved roads; and during the last African war, a road of this kind was constructed from Spain through Gaul to the Alps. After this, these great lines of communication were extended through Savoy, Dauphiné, and Provence; through Germany, and every part of Spain; through Gaul, and even to Constantinople; through Asia, Hungary, Macedonia, and to the mouths of the Danube. Neither did the interposition of seas obstruct the labour or daunt the enterprise of this great people. The lines of communication thus constructed to the shores of the continent of Europe were continued at corresponding points of the neighbouring islands and continents. Sicily, Corsica, Sardinia, England, Africa, and Asia, were accordingly intersected and penetrated by roads, forming the continuation of the great European lines. These gigantic works were not mere paths prepared for the action of the feet of horses and the wheels of carriages, formed upon the natural surface of the ground, but were constructed on principles in some respects as efficient as those which modern engineering has supplied; forests were opened, mountains excavated, hills lowered, valleys filled up, chasms and rivers bestridden by bridges, and marshes drained, to an extent which would bear no mean comparison with the result of great engineering enterprises in recent times.

In India and other countries of the East, roads were formed at an early period; and well-formed roads, with a milestone at the end of every koss, as the native mile is called, were constructed by the Moguls. Such roads connected Agra with Lahore, and Lahore with Cashmere. But after the death of Aurungzebe, these roads fell into decay, and good roads have since been constructed only by the British, who have carried an excellent metalled road, called the Grand Trunk Road,

from Calcutta to Peshawur, on the borders of Affghanistan. The metalling of these Indian roads is for the most part of kunker—a calcareous nodule deposited by the evaporation of the waters of the rivers, and found widely throughout the soil. The kunker is wetted, and is pounded down by beaters into a crust of from nine to twelve inches thick, and it forms a smooth and excellent road. In some localities the kunker is impregnated with iron, and the surface of the road in those places becomes like an iron plate.

English Roads.—The first roads of artificial construction in England, if not formed by the Romans, were at least greatly improved by their labour while it was a Roman province. A grand trunk road was carried through the country north and south, and another nearly at right angles to it east and west. These main lines were supplied with branches, extending in every direction which the conquerors found it expedient to render accessible to their arms. The road called Watling Street led from the southern shore of Kent, by Rutupiæ (Richborough) and London, through St. Albans and Stony Stratford to Caernarvon (Segontium). Ikenild, or Rikenild Street, extended from Tynemouth, through York, Derby, and Birmingham, to St. David's. The Irmin Street led from the latter place to Southampton; the Foss Way from Cornwall to Caithness, or perhaps, more correctly, only to Lincoln. (Lappenberg, *England under the Anglo-Saxon Kings*, i. 61.)

After the withdrawal of the Roman legions, the existing roads seem to have been suffered to fall into decay, while new roads were not constructed. For many centuries, such intercourse as was maintained between the various parts of this country took place almost exclusively by rude paths, capable of being passed on foot, or at best by horses, carried over the natural surface of the ground in straight directions from place to place. It was not till the reign of Charles II. that any attempt was made by the legislature to improve the roads of the country. In the sixteenth year of the reign of that monarch, the first turnpike-road was established by law. It passed through Hertfordshire, Cambridgeshire, and Huntingdonshire. It was not, however, till about a century from the present time, that any great or effectual attempts were made to establish a system of good roads through the country. Till nearly the middle of the last century, most of the goods were conveyed from place to place in Scotland on pack-horses. Oatmeal, coals, turf, and even straw and hay, were conveyed in this way; but in carrying goods between distant places it was necessary to employ a cart, as all that a horse could carry on his back was not sufficient to defray the cost of a long journey. The time usually required by the carriers to perform their journeys seems now almost incredible: the common carrier between Selkirk and Edinburgh, a distance of thirty-eight miles, spent a fortnight in his journey, going and returning. The road, for a considerable extent, lay along the bottom of the district called Gala Water; the bed of the stream, when not flooded, being the tract chosen, as the most level and easiest to travel in.

Nor were the means of travelling between large towns much better. In 1678, a contract was made to establish a coach between Edinburgh and Glasgow, a distance of forty-four miles. This coach was to be drawn by six horses, and the journey between the places, to and from, was engaged to be completed in six days; even so recently as the year 1750, the stage coach from Edinburgh to Glasgow took a day and a half to make the journey; and in the year 1763, there was but one stage coach between Edinburgh and London, which started once a month from each place, and took a fortnight to perform the journey.

It happens that the line of road now occupied by the Liverpool and Manchester Railway and its branches, and travelled daily by thousands of passengers, at a speed of thirty-five miles an hour, including stoppages, was, in the year 1770, travelled over by Mr. Arthur Young, who has left us in his *Tour* the following account of the state of the roads at that time: 'I know not in the whole range of language terms sufficiently expressive to describe this infernal road. Let me most seriously caution all travellers, who may accidentally propose to travel this terrible country, to avoid it as they would the devil; for a thousand to one they break their necks, or their limbs, by overthrows or breakings-down. They will here meet with ruts, which I actually measured four feet deep, and floating with mud only from a wet summer. What, therefore, must it be after a winter? The only mending it receives is tumbling in some loose stones, which serve no other purpose than jolting a carriage in the most intolerable manner. These are not merely opinions, but facts; for I actually passed three carts broken down in these eighteen miles of execrable memory.'

With the exception of a few rare instances of important roads, constructed under special Acts of Parliament, the roads of England have not been constructed on any scientific principle, and are, in most cases, nearly coincident with the foot and horse paths adopted by the early inhabitants of the country. These rude paths, having been formed at an early period, were gradually improved, so as to be capable of being travelled over by wheel carriages. The natural surface of the ground was in time covered with an artificial coating of gravel or stones; hills too steep to be surmounted by carriages were either levelled, and the material obtained from their excavation thrown into the valleys, or the roads were carried round them; at a later period fences were added; and thus, by slow degrees, the old horse path grew into the modern road. How far removed from a truly good and scientific line of communication such a road must be, will be apparent to anyone who considers what

the principles ought to be on which a road should be laid down and constructed.

The Art of Road-making.—When it is proposed to construct a line of road extending between two places, the engineer upon whom such a duty devolves first makes himself well acquainted with the surface of the country lying between the two places, so as to obtain an acquaintance with the face of the country, somewhat approaching to that which would be supplied by a superficial model of it, which would exhibit all its inequalities and undulations of surface. He must then select what he considers, all circumstances being taken into account, the best general route for the proposed road. But, before laying it out with accuracy, it is necessary to make an instrumental survey of the country along the route thus selected; taking the levels from point to point throughout the whole distance, and making borings in all places where excavations are required, to determine the strata through which such cuttings are to be carried, and the requisite inclinations of the slopes or slanting sides, as well of the cuttings as of the embankments to be formed by the material thus obtained. It is also requisite, in the selection of the route for the proposed road, to have regard to the supply of materials, not only for first constructing it, but for maintaining it in repair. Thus, the position of gravel pits and quarries in the neighbourhood of the proposed line, and the modes of access to them, should be well ascertained. The results of such an investigation should be reduced to a plan and section; the plan of the road being on a scale not less than 66 yards to an inch, and the section not less than 30 feet to an inch.

The loss of tractive power, and the danger to travellers produced by steep acclivities, render it especially necessary that a proper limitation should be imposed upon the inclinations or acclivities on every line of road on which much traffic is carried on. As, however, this reduction of hills in a country where much inequality of surface exists is attended with a considerable outlay of capital, the engineer will have to balance the cost of constructing a road having the best possible inclinations against the advantages to be obtained in the permanent working of the road; and if the expected traffic be not such as to yield advantages proportionate to the capital absorbed, greater rates of inclination must be allowed to the hills, with a view to diminish the extent of the works, and to render the expense of constructing the road proportionate to the traffic expected upon it.

The exact course of the road and the degree of its acclivities being determined, the next thing to be considered is the formation of its surface. The qualities which ought to be imparted to it are twofold—first, it should be smooth; secondly, it should be hard: and the goodness of the road will be exactly in the proportion of the degree in which these qualities can be imparted to it, and permanently maintained upon it. An error prevailed among road engineers until a very recent period. It was considered that smoothness of surface alone was sufficient for the perfection of a road; and that, providing it could be made sufficiently durable, it was unimportant how soft or yielding the coating of the road might be. This error, into which, among others, Macadam himself fell, was based upon a neglect of one of the most important circumstances to be considered in the construction of a road. The main object to be attained by all roads is the diminution of the resistance which a carriage opposes to the tractive power. Other things being the same, it was sufficiently apparent that this resistance would be diminished by increasing the smoothness of the road surface. But roughness or unevenness of surface is not the only cause of resistance to the tractive power. If two roads have their surfaces equally smooth and even, but one is soft and elastic, so as to yield under the pressure of the wheel, recovering its form as the wheel advances, and the other is hard and unyielding, the resistance to the tractive power will be greater on the soft and yielding road than on the hard and unyielding road; and this augmentation of resistance will be in proportion to the softness of the surface. That this must be the case, admits of immediate demonstration on mechanical and mathematical principles; but, without resorting to these, it must be sufficiently apparent from the results of the most common experience. A surface of velvet may be as smooth and even as a surface of ice; but if an ivory ball be rolled on the latter, it will continue its motion much longer than on the former. In fact, the wheels of a carriage in passing along a soft road sink into its surface, as the ball would sink into the pile of the velvet; and even if, by virtue of its elasticity, the surface of the road, like that of the velvet, recovered its smoothness after the pressure has been removed from it, still a resistance would be offered to the drawing or impelling power, which would not be produced by a hard and unyielding surface equally smooth.

Macadamisation.—This process, which has received its name from Macadam, to whose labours the improvement of the roads of England within the last half-century owes so much, consists in forming the road crust of stones, broken with a hammer into angular pieces of a small and uniform size. This method, however, is one which was long practised in various parts of Europe. When the stones of which the road crust is to be formed are broken to the proper magnitude and form, they are spread over the surface of the road in a layer of 3 or 4 inches thick. After this has been consolidated by carriages working upon it or by rollers, another layer of broken stones of equal depth is laid upon it; it is consolidated in like manner; and thus one layer is laid over another until an artificial crust is formed of broken stones of sufficient thickness to give the requisite strength to the road.

A coating or road crust thus formed might

be constructed on any substratum whatsoever, and a smooth and apparently good road would be obtained. It was the practice of Mr. Macadam to disregard the nature of the substratum; and he maintained that if it was not such a bog as would not allow a man to walk over it he would even prefer it to a hard bottom.

Telford's System.—The improvement in road-making which consisted in a due attention to the substratum or foundation of the road, so as to give increased facility to the tractive power by rendering its surface hard and unyielding, is due to the late Mr. Telford. The following is a description of the method of constructing such a road practised by that eminent engineer.

Upon the level bed prepared for the road materials, a bottom course or layer of stones is to be set by hand, in form of a close firm pavement. The stones set in the middle of the road should be 7 inches in depth; at 9 feet from the centre the depth should be 5 inches; at 12 feet, 4 inches; and at 15 feet, 3 inches; the entire width of the road being 30 feet. These stones are to be set on their broadest edges lengthwise across the road, and the breadth of the upper edge should not exceed 4 inches. All the irregularities of the upper part of this pavement are to be broken off by hammers, and all the interstices to be filled with stone chips firmly wedged or packed by hand with a light hammer; so that when the pavement is finished, its cross section shall have a convexity of surface of about 4 inches in the centre above the extreme edges: 18 feet in the centre of this pavement are to be coated with a layer of hard broken stones, 6 inches deep; of these 6 inches, 4 must be first put on and worked down by carriages and horses in the ordinary traffic of the road, care being taken constantly to rake in the ruts until the surface has become firm and the crust consolidated. After this, the remaining 2 inches of stone may be put on. The whole of this stone, forming 6 inches of crust, is to consist of pieces broken as nearly as is practicable into a cubical form, and of such a magnitude that they can pass through a ring of 2½ inches internal diameter. The spaces on each side of the middle 18 feet are to be coated with broken stone or well cleansed strong gravel up to the level of the footpath or other boundary of the road, so as to make the whole convexity of the road 6 inches in the middle above the level of the edges; and the whole of the materials thus formed and consolidated should be covered with a coating 1½ inch deep of good gravel free from clay or earth.

Such was the method practised by Mr. Telford in the construction of great main roads, such as that between Holyhead and Shrewsbury. In the streets of towns, and other places where roads have to bear a still heavier traffic, such a road as that above described is found to be subject to a superficial wear, so rapid as to produce an intolerable quantity of dust in summer and of mud in winter. In such places recourse has been generally had to pavement. The first object to be secured for a durable pavement, as well as in other roads, is to secure a good foundation. The best method is to lay a foundation of concrete, the bed of which should be formed with a convexity sloping to each side by a fall of about 1 in 50. On this foundation, when sufficiently consolidated, a pavement formed of blocks of stone is laid, the blocks being 10 inches in depth, from 10 to 15 inches in length, and from 6 to 8 inches in width. Such is the structure which is requisite for the streets which are the main thoroughfares of a great city; a pavement with less strength of foundation, and formed of smaller blocks of stone, being used for the streets of less intercourse.

The many inconveniences produced in the great thoroughfares of London, by the rapid wear of every kind of pavement hitherto adopted, by the suspension of intercourse during the frequent repairs, by the dust in summer and the mud in winter produced by a surface of broken stones, and the intolerable noise caused by every species of stone pavement, led to much enquiry as to the possibility of constructing some road with sufficient strength and durability, and presenting a surface which, while it would be free from the noise of a stone pavement, would not be attended with the inconvenience of dust and mud produced by a surface of broken stone. This problem was supposed to be in a great degree solved by the adoption of a pavement of wood. A short piece of Oxford Street was thus paved in the beginning of 1839. After a trial of several months, the same pavement was extended nearly throughout the whole extent of that street; and this method was adopted in several other thoroughfares of London. In the northern parts of Germany and in Russia such pavements have been long in use; and some of the main streets of Petersburg and Vienna have long been paved in this manner. Various methods were adopted for laying the wood pavements of London; but though every process that ingenuity could devise was attempted, none of them have been found to enable it to withstand the heavy traffic to which it was then subjected, and for such purposes wood pavement has been discarded. More recently iron pavement, consisting of perforated plates or plates with prominent projections for the horses' feet, have been tried with very moderate success, and up to the present time the best paving material is undoubtedly granite. Much might be done for the improvement of our pavements if subways were carried through all our streets, in which the gas and water companies might be compelled to lay their pipes; if vehicles were divided into low speed and high speed, each with its proper track; and if some uniformity of breadth in each class of vehicle were enforced. It would then become practicable to lay down plate tramways of iron, on which the wheels would travel with a diminished traction and a diminished noise, while the middle portion of such way, on which the

horses' feet acted, could be laid with granite pavement as at present. It will, however, be impossible much longer to accommodate the traffic of London without the construction overhead of two tiers of railway streets, crossing one another at different levels.

For further details on the subject of roads generally, the reader is referred to Sir Henry Parnell's *Treatise on Roads*. See also the *Encyclopédie*, article 'Chemin;' Bergier, *Histoire des Grands Chemins de l'Empire Romain*; *Annales des Ponts et Chaussées*; Anderson's *Commerce*; M'Culloch's 'Treatise on Commerce,' *Library of Useful Knowledge*; Mr. Telford's *Reports*.

Roasting. In Chemical Metallurgy, the protracted application of heat to metallic ores, below their fusing points. It is generally resorted to to expel volatile matters, especially sulphur, arsenic, carbonic acid, water, &c., and is generally performed in a current of air, so as to effect simultaneous oxidation.

Rob. A term of Arabic origin, applied by old pharmaceutical and modern French writers to thin extracts or inspissated juices.

Robbery (Ger. rauben, Lat. rapio, *to rob*). In Law, a felonious taking of money or goods of any value from the person of another, or in his presence, against his will, by violence or by putting him in fear: and this, whether the fear be of injury to the person's property or character. But it is necessary that the fear be of immediate injury, not of some future injurious results; and then the money must, generally speaking, be taken immediately upon the threat made, and not afterwards given from fear of consequences. But the *extortion* of money by threat to accuse of an infamous crime was made robbery by 7 & 8 Geo. IV. c. 29. The law on the subject is now collected in the recent statutes 24 & 25 Vict. c. 44, c. 96. Robbery, if accompanied by wounding, was a capital felony until the passing of the last-mentioned statute, but is not now in any case punishable by death.

Roberval's Balance. [Balance of Roberval.]

Robes, Master of the. An officer in the royal household. [Household.]

Robinia (after Jean Robin, a French botanist). A genus of *Leguminosæ*, restricted to a few North American trees and shrubs, commonly called Acacias in this country. Some, as *R. hispida*, are ornamental flowering shrubs; but the most important is *R. Pseud-Acacia*, the Locust-tree or False Acacia, which grows from fifty to eighty feet high, and yields a hard timber, much employed in the United States for posts, pales, and similar purposes, and also by carpenters and cabinet-makers, and to a more limited extent by shipwrights. It is, however, seldom of sufficient size to afford planks suitable for shipbuilding, its principal use being for the manufacture of treenails, for which it is admirably adapted; and considerable quantities of these locust treenails are exported to this and other European countries. It is also cultivated in the South of France, for vine-props. The timber is of a yellowish colour, more or less tinged with reddish-brown in the centre. The roots have the taste and smell of liquorice, but are a dangerous poison, and accidents have occurred from their being mistaken for liquorice-roots.

Roc or **Rukh.** A monstrous bird of Arabian mythology, of the same fabulous species with the simurg of the Persians. In the notes to vol. iii. of Mr. Lane's edition of the *Arabian Nights' Entertainments* are some curious extracts from writers of old voyages, designed to show that the tale was founded on the wonderful accounts of travellers, and that even Sinbad's well-known adventure, when his crew broke the roc's egg, and were attacked in consequence by the enraged pair of birds, is borrowed from the serious narration of Ibn-el-Wardee. The roc is also described by Marco Polo. (Marsden's transl. p. 707.) In a drawing from an illuminated Persian MS., which Mr. Lane has copied, the roc, or rather simurg, which is represented as carrying off three elephants in its beak and claws, is something like a cock, with eagle's wings and an extravagant tail. The simurg is a creature of Persian mythology: it is the phœnix of Oriental fable, one only living at a time, and is said to attain the age of 1,700 years. (See the notes to Southey's *Thalaba*.)

Roccella. [Orchella Weed.]

Roccellic Acid. An acid obtained from the *Roccella tinctoria*.

Roche Alum. Alum deprived of part of its water of crystallisation by heat. The term is also sometimes applied to the so-called *Roman Alum*, made from the alum ore of the Solfaterra, near Naples.

Rochelle Salt. The tartrate of soda and potassa. It is a double salt, composed of 2 atoms of tartaric acid, 1 of potassa, and 1 of soda. Its crystals, which are large and well-defined prisms, often presenting eight, ten, or twelve sides, include 8 atoms of water.

Rochet (Fr.; Ital. rochetto). A linen garment worn by bishops under the chimere. It was the ordinary dress during the middle ages, but the word itself cannot apparently be traced back beyond the thirteenth century. (Hook, *Church Dictionary*.)

Rock Butter. [Petroleum.]

Rock Cork. A variety of Asbestos. [Mountain Cork.]

Rock Crystal. A common Mineralogical term applied to transparent crystallised silica: it is also called *Quartz*. Fine specimens in this country are found in Cornwall and Devonshire, at Clifton, Gloucestershire (*Bristol Diamonds*); in Cumberland; near Cairngorm; at the Mourne mountains of Ireland (*Irish Diamonds*), and at Finglen mountain, close to Dungiven. [Cairngorm; Dungiven Crystals.]

Rock Leather. [Mountain Leather.]

Rock Marrow. [Lithomarge.]

Rock Oil. [Petroleum; Seneca Oil.]

Rock Salt. Common salt or chloride of sodium, composed of 60·4 per cent. of chlorine and 39·6 sodium. It occurs in cubical crystals, and in large beds and masses, in the waters of the sea, as well as in those of certain springs and lakes. The geological position of Rock Salt is very various, but the great British deposits of this substance in Cheshire and Worcestershire are found in the New Red Sandstone. The principal salt-works in England are at Northwich, Middlewich, and Nantwich in Cheshire; at Droitwich in Staffordshire; Stoke Prior, Worcestershire; in Durham; and in Ireland at Carrickfergus near Belfast.

Rock Shells. The common name of certain Univalves, characterised by the long straight canal which terminates the mouth of their shells. [Murex.]

Rock Soap. A hydrated silicate of alumina resembling Bole, and used for crayons and for washing cloth. It is found in basalt in Skye, and in greenish-grey or brown modules in the trap rocks of Antrim.

Rock Wood. The common name for ligniform Asbestos. It is chiefly found at Sterzing in the Tyrol.

Rocks (Fr. roc, roche, Ital. rocca). All mineral masses underlying the soil and subsoil of any part of the earth are designated by the geologist *rocks*. The term has long been in use, and is convenient.

Rocks are either fossiliferous or non-fossiliferous, the former being for the most part stratified and of aqueous origin, and the latter frequently unstratified. Of the latter some appear to have distinct reference to the action of heat or have been apparently so far altered as to be with manifest reason called igneous or crystalline. Among the former are lavas and basaltic rocks, among the latter granites and porphyries. There is a large intermediate class called metamorphic, including slates and schists.

The essential basis of stratified rocks is always either limestone, sandstone, or clay. Unstratified rocks present modifications of the same materials. Stratified rocks often contain numerous organic remains, which are rarely found in unstratified rocks.

Rocks present many mechanical modifications, resulting from the conditions to which they have been exposed.

The general classification of rocks will be found described in the article on Descriptive Geology; the details of the rocks themselves and their mechanical displacements are noticed under various heads. [Geology.]

Rocks, Structure of. Rocks exhibit a structure not less distinct and peculiar than simple minerals. The details of structure are, however, different in the two cases. The essential points of structure may be distinguished as either *concretionary*, *prismatic*, *laminated*, or *porphyritic*.

Similar mineral matter, dispersed irregularly through rocks, has a tendency to separate into bands consisting of spheroidal or flattened concretions with concentric arrangement. The structure thus induced is called *concretionary*. Many varieties of limestone, nodules of carbonate of iron in the coal measures, and the curious concretions in clay called Septaria, are of this kind.

Concretionary structure tending to produce spheroidal masses, when carried to such an extent that the whole rock is subject to it, becomes *prismatic*. It is well exemplified in the columnar basalt of Fingal's Cave and Staffa. [Basalt.] Prismatic structure extends into almost all hard rocks, producing the tendency to split in certain directions rather than others. Granite especially shows it; but limestones, when crystalline, are not less affected.

Laminated structure includes Stratification, Cleavage, and Foliation, each of which is noticed in a separate article.

Porphyritic structure is that of crystals embedded in a base, and is also noticed in the articles on Granite and Porphyry.

Rocket (Ger. rackete, Ital. raggetto, from Lat. radius, *a ray*). In Artillery, a cylindrical case of paper or metal, containing inflammable composition. To one end of the case is attached a head usually conical or cylindro-conoidal; the other end is closed, but has one or more vents for the escape of the gas from the ignited composition. A conical cavity is left in the rocket, its base coinciding with that of the rocket; by this means a large surface of composition is ignited at once, and so great a quantity of gas is generated that it cannot escape from the vent as quickly as formed, and therefore it exerts a pressure in every direction inside the rocket. The pressures on the sides balance each other, but that on the head is greater than that on the base, from the escape of gas through the vents. This excess of pressure imparts motion to the rocket in the direction of the head, and continues to do so until the composition is all consumed. A stick or long rod is attached to the rocket, to counteract, by the resistance of the air upon it, any tendency to rotation round the shorter axis.

The war rockets at present in our service were invented by Sir William Congreve; their heads contain powder, and can be made to act as shells. They are fired from tubes raised above the ground. Signal rockets contain star composition in their heads, and are fired vertically.

It has been found impossible to obtain any accuracy of fire with Congreve rockets, and so they can be used only against objects covering much ground. Mr. Hale has introduced a rocket, giving much greater accuracy of fire, to which a rotation round its longer axis is communicated by the action of the gas issuing from the vents on flanges outside them.

Rockets have been defined as 'ammunition without ordnance, the soul of artillery without the body.' They were probably used in China long before gunpowder was employed to propel shot; and we find them in Italy in 1397, under the name of *rochettæ*.

Sky-rockets are much used in displays of fireworks; a large number, technically called a *bouquet*, being often discharged simultaneously. For this purpose the heads are generally filled with various compositions, producing stars or balls of different colours. Upon the bursting of the head, which occurs when all the rocket composition is consumed, these are ignited and descend in a brilliant shower.

Rocking Stones. [LOGAN STONES.]

Rockwork. In Architecture, masonry wrought in imitation of rough stone, in various arrangements, and used chiefly in the basements of houses, or in such situations as require the effect of solidity and massiveness.

ROCKWORK. In Gardening, this term is applied to a quantity of stones, fragments of rock, or even vitrified bricks, piled together in such a manner as to form a nidus for the growth and display of alpine plants. The materials are sometimes covered with a grouting of cement. When the pieces of rock are of such forms as can be connected together so as to present the appearance of stratification, that mode of arranging them may be adopted; and the soil and plants may be placed in vertical, oblique, or horizontal fissures, or on ledges, according to the lines of stratification. When, however, as is most frequently the case, land or water-worn stones are used, they may be distributed over a mound of earth, not uniformly, but in groups, with smooth surfaces of soil between, as where stones of different sizes are seen cropping out of the surface of a green hill or hillock. When agglutinated masses of vitrified bricks are used, either alone or mixed with land stones of different sizes, they may be distributed over a mound, or along a bank of soil, in such a manner as to produce a varied surface, without attempting to imitate nature, and with interstices between them for inserting the plants. Imitations of conical hills, caverns, precipices, and even the Alps, on a small scale, have been made in rockwork; but these, and all other imitations of nature, require to be designed and directed by the eye and mind of an artist. In general the piles of stone called rockwork, in gardens, might with more propriety be called heaps of stones.

Rocky Mountains. These mountains consist of two parallel ranges, occasionally united, and extending from the plateau north of Mexico, nearly parallel to the west coast of North America, to the Arctic Ocean. Both ranges are comparatively low at first, but rise into groups of very lofty mountains, frequently above the snow line as they advance northward. The range generally is barren and desolate, but the valleys between the mountains are long, narrow, and rich.

The length of range of the Rocky Mountains is nearly 18,000 miles, but the width is not very great. The chief elevations (ranging to nearly 16,000 feet) occur between the fiftieth and sixtieth parallel, though some lofty mountains are as low down as latitude 40° N. Most parts of the chain are as much as 300 miles from the coast.

The principal sources of the great rivers of North America, with the exception of the St. Lawrence, are to be found in the valleys on the eastern side of the Rocky Mountains; and the gold deposits of California and Oregon occur in the valleys between the mountains of this chain and the subordinate coast range.

Rococo. The name given by the modern French architects to anything ancient and out of fashion; but it has been especially applied by them to those tormented decorations of the period of Louis XIV. and Louis XV. which have become as much the objects of horror to the architects of the present day, as they were once the fashion. Interrupted pediments, columns made stouter at the top than they are at the bottom, broken curves and ornaments, tortured in every shape and style, constitute the picturesque but illogical style generally known as the *rococo*. The English never adopted this style except in their furniture.

Rod (Dan. rode, Dutch roede). A measure of length, otherwise called a *pole*. It is $5\frac{1}{2}$ yards, or $16\frac{1}{2}$ feet; and four of these make the *Gunter's chain*.

Rodents (Lat. rodo, *I gnaw*). The name given by Cuvier to the *Glires* of Linnæus, an order of Lissencephalous Mammals, comprehending those which have two long chisel-shaped incisors in each jaw, and no canines, but a vacant interspace between the incisors and the molars. The lower jaw is articulated by a longitudinal condyle, in such a way as to allow of no horizontal motion, except from back to front, and vice versâ, as is requisite for the action of gnawing. The molars also have flat crowns, whose enamelled eminences are always transverse, so as to be in opposition to the horizontal motion of the jaw, and to increase the power of trituration. The genera in which these eminences are simple lines and the crown is very flat, are more exclusively frugivorous; those in which the eminences of the teeth are divided into blunt tubercles are omnivorous; while the small number of such as have no points more readily attack other animals, and approximate somewhat to the Carnaria. The form of the body in the Rodentia is generally such that the hinder parts of it exceed those of the front, so that they rather leap than walk. In some of them this disproportion is even as excessive as it is in the kangaroos. In the whole of this class the brain is almost smooth, and without furrows; the orbits are not separated from the temporal fossæ, which have but little depth; and the eyes are altogether lateral. The inferiority of these animals is visible in most of the details of their organisation. Those genera, however, which possess stronger clavicles have a certain degree of dexterity, and use their fore feet to convey their food to the mouth.

Rodomontade. A term that has passed into most European languages; from Rodomont,

a boisterous character in the *Orlando Furioso.* The name is probably a corruption of RHADAMANTHUS.

Roe (Ger. rogen, meaning originally *fruit*). The ova of osseous fishes which are developed simultaneously and in great numbers are so called.

Roesslerite. The name given by R. Blum to a newly discovered hydrated arseniate of Magnesia, from the Kupferschiefer of Bieber.

Roestone. A granular limestone, or oolite.

Rogations (Lat. rogatio, from rogo, *I ask*). In the Ritual, public supplications or litanies were anciently so termed, until the latter designation began to supersede every other. (Palmer, *Orig. Liturgicæ*, vol. i. p. 270.) In the Ecclesiastical Calendar, the three Rogation days are the Monday, Tuesday, and Wednesday next before Ascension-day.

Rogue's Yarn. A yarn of a different twist and colour from the rest, and inserted in the royal cordage, to identify it in case of theft.

Rohitas (Sansc.). In the Veda, the rays of the sun are called by this name, which, like that of the CHARITES, was originally a mere adjective signifying *brown*, but came at length to signify some special animal of that colour. Thus the white horses of the sun were called the *Arushîs.* [EROS; SIGURDR.]

Roland. In the cycle of the Carolingian myths, a Paladin of Charlemagne, who fell at the battle of Roncesvalles. The memory of this battle is preserved in the spirited Basque song of Attabiscar, which M. Francisque Michel (*Le Pays Basque*, p. 235) ascribes to the age of which it speaks. (*Edinburgh Review*, April 1864, p. 383.) This fight is also mentioned by Eginhard in his *Life of Charles the Great*, c. ix., and from this writer we receive the name of a Roland (Hruodlandus, Britannici limitis præfectus), who was there slain. This Roland, whose whole authentic history is contained in this solitary notice, is supposed by some to be the Roland of the epic cycle; and thus the fact mentioned by Eginhard is regarded as the historical substratum underlying the legend, and perhaps giving rise to it. This circumstance has led Mr. Freeman (*Fortnightly Review*, No. xxiv. May 1, 1866) to classify myths as quasi-historical and quasi-theological, the tales of Zeus, Dêmêtêr, and Heracles belonging to the latter class, those of the Trojan war and the Carolingian epic to the other. From the supposed conclusion that the notice of Eginhard proves Roland to have been a real man, Mr. Freeman gathers that his famous legendary death is a very easy perversion of his historical death; and he thus expects to find about the same amount of truth in the legend of the Trojan war which he finds in the Carolingian myths. In reply to this it has been asserted that the truth, if found at all, is obtained, not from the legend, but from the contemporary notice of Eginhard, without which the myth would for all historical purposes be absolutely worthless; and that without similar contemporary notices of persons named in the Homeric poems the tale of Troy is destitute of all historical value, and that, therefore, while the existence of such persons cannot be denied, so neither can it be affirmed. The danger of theorising from the mere occurrence of names is further pointed out in the article SIGURDR, where it is shown not only that the names of persons who lived in the fourth and succeeding centuries are introduced into the *Nibelungen Lied*, but that the fortunes ascribed to the persons so named agree singularly with their actual fortunes as known to us from contemporary historical documents, while these names and the adventures assigned to them are merely modifications of names and incidents found in the far earlier *Volsunga Saga.*

Rolle's Theorem. In the *Theory of Equations*, this theorem establishes the following important relation between the roots of an equation $F(x)=0$, and of the roots of the derived equation $F'(x)=0$, where $F'(x)$ is the first derived function of $F(x)$. *Between each pair of real roots of an equation occurs at least one real root of the first derived equation.* From this theorem it follows that: 1. The primitive equation cannot have more than one real root between any pair of adjacent roots of the first derived equation. 2. It cannot have more than one root greater than the greatest root of the derived equation, nor more than one root less than the least. 3. The primitive having m real roots, the first derived equation will certainly have $m-1$, and the r^{th} derived equation will have at least $m-r$ real roots. 4. The primitive will have at least as many imaginary roots as any one of its derivatives.

Rolle was a French mathematician of the seventeenth century. His treatise on Algebra was published in 1690.

Roller. In Printing, a cylinder of wood coated with a composition of treacle and glue, and revolving upon an iron rod running through it, with which to ink the form of type previous to taking an impression. The introduction of composition rollers in place of pelt balls has been the cause of a complete change in printing. But for this invention, machine or cylindrical printing could never have been accomplished, as all the early attempts with sheepskins failed, from the necessity of joining the edges.

Rollers. In the service of ordnance, cylinders of wood, used in mounting guns on their carriages, shifting them from one carriage to another, or moving them on the ground.

ROLLERS. In Ornithology, a family of birds (*Coraciadæ*) of the order *Volitores*, of which there is one European species, *Coracias garrula*, of a vivid sea-green colour with some purple and red marks, about the size of a jay: they have a great and varied power of flight, and are chiefly insectivorous.

ROLLERS. On Shipboard, certain cylindrical pieces of timber placed so as to revolve horizontally or vertically. Their object is to lessen the friction on the hawsers in passing any angle.

Rollers. The name given by seamen to unusually heavy waves, which set in upon a coast or island without wind. They are frequent at the island of Ascension.

Rolling. In Mechanics, this term is used when all the parts of the surface of one body come into successive contact with those of another, under such conditions that at every instant the portion of the two surfaces which *have been* in contact are exactly equal. When this condition is not fulfilled, the one surface is said to slide upon the other. The friction of bodies in rolling is much less than in that of sliding; and hence the advantage of wheels to all kinds of carriages. [Friction.]

Rolling. In Naval language, the lateral oscillation of a vessel. This motion, which is often very great when the vessel is running before the sea, endangers the masts, strains the sides, and loosens the decks at the waterways; it also tends to cause the guns to break adrift. When the centre of gravity is too low, the oscillations begin and end violently. The changes in the stowage necessary to modify the nature or extent of the roll are made by seamen from experimental knowledge.

Rolling is, in fact, an oscillation or partial revolution round the centre of gravity of the ship. Of course if the centre of gravity be too high up, the vessel's tendency will be to capsize: but on the other hand, if it be far below the load-water-line, there remains so little depth of vessel and keel for the water's resistance to operate on, in opposition to the height of hull and masts above the centre of gravity, that the rolling will necessarily be violent and considerable. The least rolling is experienced when the centre of gravity coincides nearest with the load-water-line.

Rolling Curves. [Roulette.]

Rolling Mills. In Mechanics, massive rollers connected by toothed pinions and put in motion by a steam engine, for the purpose of rolling out metal into bars or plates. Such mills are most used for rolling iron, though used also for rolling copper, silver, and other metals into thin sheets. The rollers are fixed in massive framing, which has to support a prodigious strain; for rolling bars they are grooved, but for rolling plates they are plain. In rolling iron the *bloom*, as the mass of heated metal is called, is drawn in, and compressed and elongated in passing through. The bar so formed is passed through a succession of similar grooves, decreasing in size till it is reduced to about four inches in width, from three-quarters of an inch to an inch in thickness, and from ten to twelve feet in length. In this state if the bloom has been taken from the puddling furnace it is termed *puddle bar*. The bars are then cut into pieces, piled, heated, &c., and a second time rolled. The bars produced by this second process are called *merchant bars*; or the bloom may be rolled into plates. The trains of rollers used in iron-works are distinguished by several special names. Thus the first pair employed in working the rough or puddled bars, are known as the *forge train*, *blooming mill*, or *puddle-bar train*, the term *train* in all cases meaning a series of two or more pairs of rolls connected together and worked as one system. The trains used in producing finished iron are known as *merchant-bar*, *plate*, *rail*, and *wire mills*, according to the section produced. The first pair of rolls in a train is known as the *roughing-down*, and the last as the *finishing* rolls.

In rolling heavy masses of iron, such as boiler or armour plates, where the pile or bloom cannot be lifted back over the top of the mill, the rolls must be reversed after each passage, and the pile is passed backwards and forwards alternately; on this plan it is, however, impossible to work with any speed. One arrangement to obviate the necessity of reversal is the *three high train*, in which three rollers are placed vertically above each other in the same housings, so that the middle roll moves above its centre in the same direction as the upper one, and below the centre as the lower one, forming a complete double pair moving in opposite directions, so that the iron may be passed backwards and forwards without reversing the motion of the driving power. The universal rolling mill is a combination of a vertical pair of rolls with the ordinary horizontal pair, so that a pile may be welded by pressure on all sides at the first heat without burning.

The *slitting mill* is a kind of rotatory shears used in cutting up bars of iron into nail rods.

The horizontal, non-condensing steam engine, from its compact form and convenience of handling, is well adapted for giving motion to the machinery of iron works. It is cheaper in its original cost, and all its parts being fixed upon a large bed plate, it needs a comparatively small amount of masonry to render it solid and secure. But whatever form of engine may be employed, it is indispensable to the efficiency of the mechanism that a very large and swift fly-wheel shall be introduced, which will absorb power when there is no iron passing through the mill, and give power out when the mill is labouring under a heavy charge. The fly-wheel attached to the engine set up at Millwall by Boulton and Watt for rolling armour plates weighs 100 tons.

Rolling Pendulum. A cylinder caused to oscillate in small spaces on a horizontal plane. Its mathematical expressions are interesting, but it has been applied to no important practical purpose.

Rolling Tackle. A tackle or pulley hooked to the weather quarter of a yard, and to a lashing or strap round the mast near the slings or parral of the yard; the object of it is to keep the yard constantly over to leeward, thereby depriving it of play and friction when the ship rolls to windward.

Rolls of Court. The archives of a manor, in which are recorded the surrenders and admittances of tenants and the other business done at the manorial courts, &c.

Rolls, Master of the. A high officer of the Court of Chancery, second only to the lord chancellor. He is appointed by the crown by letters patent, and holds his office for life. The Master of the Rolls administers justice in a separate court. He has the power of hearing and determining originally the same matters as the lord chancellor, excepting cases of lunacy and bankruptcy; but all orders and decrees pronounced by the Master of the Rolls must be signed by the lord chancellor before they are enrolled. The Master of the Rolls is the keeper of all the records of the Court of Chancery after the decrees and orders have been enrolled; and on that account he was anciently styled *guardien des rolles*. The Master of the Rolls ranks immediately after the Chief Justice of the Queen's Bench: his salary is 6,000*l.* a year.

The Master of the Rolls formerly held his sittings only in the evening, and until the year 1833 he did not hear motions, pleas, or demurrers; and whatever was presented for his decision, other than the hearing of causes, was brought before him by petition. In the year 1833, however, this was altered; and motions, pleas, and demurrers are now heard by him in the same manner as by the other equity judges. By the Act 1 & 2 Vict. c. 94, entitled 'An Act for the better Custody of the Public Records,' the Master of the Rolls for the time being is intrusted with the custody both of the public records and those of the common law courts and the Court of Exchequer.

Rollster. [ROSTER.]

Romaic. This name is sometimes applied to the language of the modern Greeks, who call themselves Romans, an appellation which has survived the overthrow of the Roman Empire of the East established at Constantinople.

The language differs from the ancient Greek chiefly by the abbreviation of words, indifference to the old inflexions, and the infusion of foreign words and expressions. But a distinction must be drawn between the modern Greek of newspapers and literary writers like Tricoupes, whose language is readily intelligible to all who are acquainted with old Greek, and the more remote popular dialects, which are practically a different language. (Hallam, *Literary History*, part i. ch. ii. § 13.)

Roman Alum. An alum extracted from the volcanic rocks of the Solfaterra near Naples; it crystallises in opaque tubes, and contains more alumina than the common octahedral alum.

Roman Architecture. [ARCHITECTURE.]

Roman Catholics, Romanists, or Papists. Names applied to the members of the church which regards the bishop or pope of Rome as its spiritual head, and asserts an exclusive claim to the title Catholic or universal. [MASS; PAPACY; PENANCE; PURGATORY; TRANSUBSTANTIATION; &c.]

The Roman doctors hold that the Scripture is not sufficient for its own interpretation. The books which compose the canon of the New Testament are, they conceive, desultory and incomplete; being many of them written for special occasions, at a period considerably later than the foundation of the religion in various districts, in some of which whole generations of believers may have passed away without having seen or heard of their contents. It is not to be supposed, however, that doctrines so important as those shadowed forth in the Epistles of St. Paul, or the Gospel of St. John, could have been left untaught to the churches which flourished before their publication or beyond their reach. It must be admitted, therefore, they argue, that the first preachers of Christianity must have been commissioned and instructed to deliver these same doctrines orally; and it is affirmed that several important doctrines are imperfectly developed in Scripture, and would not be understood, except for some such illustration by the way, the result of which is conveyed in the creeds of the first centuries. It is also affirmed that the practice of the primitive church, the infallibility of which is assumed, authenticates various articles of Roman belief, of which only very slight hints are to be found in Scripture, and such, perhaps, as would not have been discovered but for this very evidence of early usage. This line of argument is admitted also by many Protestants, the facts alleged being disputed, and opposite results being thus obtained. It must be allowed, however, that Roman Catholics do not advance any article of belief without pointing out some supposed ground for it in Scripture, although the only proof of this kind is in some cases to be found in writings which Protestants esteem apocryphal. But while Protestants may refer to the practice of the primitive church, and to the traditions which must have circulated in those ages, as genuine historical evidence of the theology of the earliest times, they find too much contradiction in the individual witnesses to consider any one system *deduced therefrom* as infallibly right. The Roman theologians, on the contrary, attaching more importance to this kind of evidence, and labouring under the same difficulty with Protestants in discriminating between genuine and corrupt traditions, take refuge in the position that the pope, as the vicar of Christ, is the authorised interpreter of tradition, and maintain that the dogmas which have been advanced from this source have always been those of the Catholic church, and always authentic. In later times, however, a question has been much agitated respecting the relative authority of popes and councils. The superiority of each has been maintained by different classes of theologians, and it is certain that in some cases the decisions of popes have been ultimately reversed by councils. It is now commonly supposed, by those who judge from the general appearance of things in the theological world, that the theory which ascribes infallibility to the pope alone is gaining ground over the theory so strongly urged in the days when *Cismontane* or *Gallican* opinions prevailed,

namely, that it was to be found only in the decrees of the pope in council; and the assumption of authority by the present pope, in fixing the dogma of the Immaculate Conception, is said to give countenance to those who hold that *Ultramontanism* is for the time prevalent. In a broad sense, the term *Roman Catholics* comprehends certain communions which have become subject by their voluntary act to papal jurisdiction, although retaining some rites and practices of their own, of which the *United Greek Church* is the principal.

Roman Order. [COMPOSITE ORDER.]

Roman School. This school of painting, which, like the Florentine, addressed itself to the mind, is formed upon antique models, and is chiefly distinguished for form and expression. Its style was poetical; embellished with all the grandeur, pathos, and freedom from common matters, that the happiest imagination could conceive. In touch its masters were easy, correct in drawing, learned and full of grace. The heads of the figures are always drawn with great respect to truth and expression, and it exhibits great intelligence in contrasting attitudes. The colouring displays the greatest marks of negligence in this school, which in draperies is eminently successful. At the head of this school was Raphael; and among its other principal masters were Giulio Romano, Perino del Vaga, Michael Angelo da Caravaggio, Barocci, Andrea Sacchi (perhaps the best colourist of thi school), and Carlo Maratti. [PAINTING.]

Roman Vitriol. Sulphate of copper, or blue vitriol.

Romance (Fr. roman, Ital. romanzo). In Literature, a work of fiction in prose or verse, containing the relation of a series of adventures either marvellous or probable. A tale confined to the latter class of events has, indeed, been considered to be more strictly designated by the term *novel*. [NOVEL.] But as our nomenclature for works of fiction is not very precise or accurate, the name *romance* is very frequently used to comprehend both.

The term *romance* is derived from the class of languages in which such fictitious narratives, in modern times, were first widely known and circulated. These were the tongues derived from the Latin, viz. Italian, Spanish, French, which were all Roman dialects, in contradistinction to the European languages of Teutonic origin. But the *langue Romane* more properly signifies the dialect of Southern France, Catalonia, &c., of which the Provençal was a variety.

The famous *Milesian Tales* of antiquity are thought to have been, in classical times, the class of writings nearest approaching to our modern romances. All the original Greek compositions of this kind have perished. But we have, in the *Golden Ass* of Appuleius, a Latin imitation of these, written in the later times of the Roman empire. [PSYCHE; VENUS.] It contains a series of wonderful adventures, sorceries, transformations, love, religion, &c.; and although it has been asserted that the romance, in its proper sense, was unknown to the ancients, it would be difficult to say in what respect, except the total absence of chivalrous sentiment, which is of modern growth, this curious fragment differs from those later inventions which we have agreed to call by that name.

The same may be said, and with even greater strictness, of the Greek pastoral romances; a class of works appertaining to a later period, of which the famous *Daphnis and Chloe* of Longus is the first known specimen. They contain narratives of amours, adventures, &c., usually intermixed with some supernatural interference; and they have the great characteristic of a modern novel—a pair of lovers, by way of hero and heroine, whose attachment is generally brought to a happy termination.

The earliest modern romances were collections of chivalrous adventures, founded chiefly on the lives and achievements of the warlike adherents of two sovereigns, one of whom, perhaps, had only a fabulous existence, while the annals of the other have given rise to a wonderful series of myths—Arthur and Charlemagne. These romances were metrical compositions in that branch of the modern French language termed the *langue d'oil*, which prevailed throughout the north of France, and especially in Normandy. Besides these, a great variety of smaller tales, some chivalrous, some marvellous, some simply ludicrous, termed *fabliaux*, exist in the same language. The date of these compositions extends from the twelfth to the fifteenth centuries.

From the hands of these rhymers the tales of chivalry passed first into those of prose compilers, who reduced them into a form more resembling that of our modern romances. The French prose romances of chivalry, still confined to the same classes of subjects, belong to the fourteenth and fifteenth centuries. These, again, gave birth in two different countries to two widely differing series of works of imagination. In Italy, the poets termed Romanzieri, taking the adventures of the knights of Charlemagne as their subject, transferred the rude conceptions of their predecessors into one of the most finished and enchanting forms of poetry to which modern fancy has given birth. Boiardo, in the latter half of the fifteenth century, was the first of these poets; and the names of Pulci, Ariosto, and Tasso, three of the greatest in Italian literature, grace their long catalogue. In Spain and Portugal a new class of chivalrous romances was called into existence. Lobeira, a Portuguese, in the fourteenth century, composed the first four books of *Amadis de Gaul*. This famous work resembles in character the French romances of chivalry; but narrates the exploits of a new and entirely imaginary hero. *Amadis* was finished, and a long list of similar romances added to it, by subsequent Spanish and Portuguese writers. In these, while adventures became more and more marvellous, the fanciful spirit of chivalry was more and more carried into wild exaggeration. They became, however, so popular as to be transplanted into most

European languages, and even in France to supersede the heroic tales of Arthur and Charlemagne. They declined with the advance of a better taste in literature after the art of printing had been for some time introduced; and were finally driven out of fashion by the wit of Cervantes, whose *Don Quixote* is aimed in great measure against them.

Meanwhile, a new species of fiction had acquired vogue in Italy, to which the term *novel* was first applied. This was the amorous or humorous tale; of which the *Decameron* of Boccaccio contains the earliest and by far the most popular collection. The stories were derived from many originals; but especially from the *fabliaux*, of which mention has been already made. The Italian Novellieri are extremely numerous; but their compositions are always short, and would, in our modern language, be designated by the term *tale*, rather than *novel* or *romance*. They flourished in the fifteenth and sixteenth centuries. From these, again, was derived the comic satirical tale of Spain; a more sustained and longer class of composition, of which *Lazarillo de Tormes* and *Gusman d'Alfarache* are the best known specimens. But in these, which were also caricatures of the chivalrous romances, a long course of independent exploits of the hero formed the substance of the work, and not a story possessing an individual point and interest.

Don Quixote, of which the first part was published in 1609, was the joint result of the romances of chivalry, which it was intended to ridicule, and of the romances of low life, of whose character it contains a large intermixture. Although Cervantes had in view rather the satirical object of his writing than the direct delineation of manners and occurrences, such as we now expect in a novel, yet it may be fairly said that his immortal work is the first of its kind in which human nature is brought on the stage alike unadorned and undegraded; neither exaggerated by the ridiculous costume of chivalry, nor lowered by the familiar buffoonery of a comic tale. While, therefore, it has been the source of numerous imitations in its satirical character, its wide popularity has produced much more lasting effects in another manner: it gave the first example of a work of fiction in which the grave and gay events of life might be mingled together, and in which, also, the views and sentiments of the author might be conveyed through the medium of fictitious personages and events.

On the other hand, the chivalrous romance had been seized, at an earlier period, by a very different genius from that of Cervantes, and applied to another object. The fictions of Rabelais (the *Histories of Gargantua and Pantagruel*) cannot be termed romances; but their popularity was so great that France was inundated for more than a century afterwards with Rabelaisian tales; and many of the elements of the modern low romance, such as comic hyperbole, eccentric humour, and much freedom and grossness of delineation, have been undoubtedly derived to us from Rabelais and his admirers. Swift and Sterne were both essentially imitators of this singular genius.

In the seventeenth century Le Sage naturalised the Spanish romance in France. His works present a singular mixture of different styles, although all derived from the same country. In *Gil Blas*, for example (if that work be not actually of Spanish origin), we have something of the humour of *Don Quixote*, the form as well as much of the substance of *Guzman d'Alfarache*, &c.; and much intermixture of a class of tales of love and intrigue, which, coming originally from the Italian novellieri, had acquired a certain chivalrous colouring in passing through the hands of Spanish imitators. There is, moreover, a touch of French taste and philosophy, such as afterwards, when mixed with satire, gave birth to the modern philosophical tale or romance, of which Voltaire's writings contain the best known specimens.

After Le Sage, a new class of romances suddenly grew into fashion in France, the heroic; derived, indeed, in part from an earlier source, the pastoral romance of the sixteenth century. Of these, the *Clélie* and *Cassandre* of Mademoiselle Scudéry were among the most popular examples, although they have long ceased to be read. This species of composition was, in fact, a revival of the old chivalrous romance, without its supernatural marvels, but with even greater exaggeration of sentiment. Its temporary success is to be attributed rather to a caprice of fashion than to the natural progress of taste. It was not, however, wholly without its use, as it called back some degree of sentiment and high feeling into the romance which was in danger of degenerating wholly into a comic cast.

During the eighteenth century the romance and novel enjoyed a popularity, both in England and France, which threw comparatively into the shade every other species of fictitious literature. It would be impossible to continue such a sketch as the present, so as to trace out the various styles and species of those compositions which grew into vogue by the success of distinguished writers in each respective branch. In England, Richardson transferred into ordinary life somewhat of the refined sentiments which distinguished the heroic romance, and thus formed the basis of the modern English novel, properly so called, or novel of manners. His *Pamela* appeared in 1740; his last work, *Sir Charles Grandison*, in 1753. Fielding and Smollett, about the same time, revived the old comic romance, adapted to English scenes and characters. Sterne did the same by the humorous or Rabelaisian style of writing; but added an intermixture of pathos which had certainly never been joined before with so incongruous a companion. To these four writers, in conjunction with Goldsmith's *Vicar of Wakefield*,

confessedly an independent original, almost all the English fictitious prose literature of the last century which is not imitated from foreign works may be said to owe its existence. In France, Marivaux, Prévost, and, with a worse taste than theirs, the younger Crébillon, formed the national manner in this class of writing for some time. Their productions have much of the same character with those of Richardson, but a far lower tone of morality, and less life-like description. But the popularity of the famous *Nouvelle Héloïse* gave a new turn, not only in France, but over Europe, to the public taste in this branch of writing. Marivaux and Prévost may be said to have been Rousseau's models, as to the externals of his great romance; but its tone and sentiment are peculiarly its own. In France, after many inferior imitators, Madame de Staël, the first of female novelists, must be classed as the best and latest disciple of the school of Rousseau. In Germany, his style had even greater success; and he may be said to have called into life at once the taste and the power of that people for fictitious composition. Wieland, Kotzebue, Goethe (*Sorrows of Werther* and *Wilhelm Meister*), are all, though with much originality of their own, essentially followers of Rousseau; Lafontaine, and many other inferior writers, more direct imitators.

In our own times, while the novel of manners continues to maintain its empire in popular estimation, another species of romance—the historical—has likewise acquired a powerful hold on the public taste, which, even more than the first, is chiefly of English origin. The historical romance, in which fictitious scenes and personages are made to serve as vehicles for the historical portraiture of past times, had, especially in Germany, been cultivated with success before the writings of Sir Walter Scott; but it is to his adoption of this branch of composition, and the extraordinary talent which he devoted to it, that its recent popularity may be traced.

Romance Languages. A name given to those modern languages which are closely akin to the old language of the Romans, and which are modifications of the ancient Italian dialects: of these, six still remain literary dialects, the languages of Portugal, Spain, France, Italy, Wallachia, and the Grisons of Switzerland. The Provençal, or language of the Troubadours, is now a mere patois. [LANGUAGE.]

Romancero. In Spanish, the general name for a collection of the national ballads or *romances*; so called from the word *Roman* or *Romanic*, which, in the early part of the middle ages, seems to have been the common appellation of all the dialects spoken from the Alps to the western extremity of the Mediterranean. The *Romancero General*, the most celebrated of these collections, was published in 1604–14.

Romanese Language. The language of the Wallachians, who call themselves Romàni. It is spoken in Wallachia, Moldavia, and in parts of Hungary, Transylvania and Bessarabia, and is divided by the Danube into two branches, the northern being to a certain extent a literary language; the southern has borrowed many Greek and Albanian words, and has never been fixed grammatically. (Max Müller, *Lectures on Language*, first series, 182.)

Romanesque (Fr.). In Architecture. [ARCHITECTURE, GOTHIC.]

ROMANESQUE. In Painting, appertaining to fable or romance. In historical painting, it consists in the choice of a fanciful subject, rather than one founded on fact. *Romanesque* is different from *romantic*; because the latter may be founded on truth, which the former never is.

Romantic, Romanticism. By *romantic* is understood that singular intermixture of the wonderful and mysterious with the sublime and beautiful which introduces us into an enchanted existence. [CHIVALRY.]

Almost all authors agree in acknowledging the difficulty of giving a precise signification to the term *romantic*. The *Dictionnaire de l'Académie Française* says, 'Le romantique est un genre nouveau. *Romantique* se dit encore des écrivains qui affectent de s'affranchir des règles de composition et de style établies par l'exemple des auteurs classiques.'

The term *romanticism*—an offshoot of romantic—is of recent invention, and is applied chiefly to the fantastic and unnatural productions of the modern French school of novelists, at the head of which are Victor Hugo, Balzac, 'George Sand,' &c., and their imitators in France and other countries.

Romanzieri. In Italian Literature, a series of poets who took for the subject of their compositions the chivalrous romances of France and Spain; and chiefly those relating to the exploits of Charlemagne and his fabulous Paladins. [ROLAND; SIGURDR.] The earliest of these poets flourished in the latter end of the fifteenth century. Boiardo, although not absolutely the first in order of time, is considered as having laid the groundwork, in his *Orlando Innamorato*, of the edifice of fiction raised by his successors. Pulci, in the *Morgante Maggiore*, was the first who allied the romantic incidents and sentiments of chivalry with light and humorous satire. Berni remodelled the work of Boiardo. Ariosto, in the *Orlando Furioso*, carried this species of poetry to the highest degree of perfection. These are the four principal Romanzieri; but many other poets of the same school flourished until the end of the sixteenth century. Tasso composed one of his early poems (*Il Rinaldo*) on the common model. In the beginning of the eighteenth century, Fortiguerra compiled his *Ricciardetto*, a poem of a semi-burlesque character, intended originally as a parody, but completed as a serious composition; and thus closes the list of the Romanzieri. All these poets adopted the OTTAVA RIMA, invented by Boccaccio. In their poems the thread of the main narration is frequently interrupted by a multiplicity of minor adventures

and intrigues; and this complication of plot appears to have constituted one of the characteristic features of the chivalrous epic. In most of them (from the time of Pulci) each book begins with a sort of prologue, more or less connected with the subject which follows: and these prologues form perhaps the greatest charm of the poem of Ariosto, effecting the transitions from one subject to another by means of some touch of pathetic or elevated reflection, or of light humour and playful satire, generally in the form of an address to the supposed audience, the poem being framed on the model of a tale recounted by a minstrel to an assembly of knights and ladies.

Romanzowite. A brown or brownish-black variety of Lime-Garnet occurring in compact or crystalline plates, at Kimito in Finland. It is a triple silicate of lime, alumina, and iron, and was named after Count Romanzow.

Romeine or **Romeite.** A native antimoniate of lime found in the manganese mines of St. Marcel in Piedmont, and named in honour of the celebrated crystallographer Romé de l'Isle.

Romulus (Lat.). In Mythology, the supposed founder of the city of Rome, of which he is the eponymous hero, as Arcas is of Arcadia, and as Ion, Æolus, and Dorus represent respectively the Ionians, Æolians, and Dorians. In its several incidents the tale of Romulus presents a close parallel to the legends of other mythical heroes. The resemblance to the myths of Cyrus and Chandragupta (Max Müller's *History of Sanskrit Literature*, 283 &c.) is especially striking. In all these, as in the tales of Paris, Œdipus, Telephus, and Perseus, there is the exposure of the children and their wonderful rescue, generally by some beast in the first instance, as a wolf [LYCAON], a bear [RISHIS, THE SEVEN], or a dog. In all cases the children grow up pre-eminent in grace and majesty, and their royal bearing is the cause which leads to the discovery of their parentage. Like ŒDIPUS, Romulus is taken from the sight of men in a storm of thunder and lightning. [QUIRINUS.]

The incidents of his reign are made up of local and institutional legends, as of the Asylum, the Lupercalia, of the Ramnenses, Titienses, Luceres, &c., while into these tales later writers introduced the element of plausible fiction. But, as in the annals of the Teutonic conquests in England, the chronology is altogether artificial. The heroic secle was a period of 77 years, and this secle was made to include the reigns of Romulus and Numa; and as the cyclical year was divided into 38 nundines, one of these was assigned to the interregnum, and 37 were given to the reign of Romulus. Thus, if twice 38 were to be allotted to the first two kings, 39 fall to Numa's share; and this period is assigned to the latter in one account. In Livy, Numa's reign is stated at 43 years; but if this sum be added to the 37 of Romulus with the year of interregnum we have 81, the biquadrate of 3. (Niebuhr, *Hist. of Rome*; Sir G. C. Lewis, *Astronomy of the Ancients*, p. 50; Lappenberg, *Hist. of England*, i. 77.) [TABULATION OF CHRONOLOGY.]

Rondeau (Fr.). In French Poetry, a little poem of thirteen verses, divided into three unequal strophes, with two rhymes (eight lines masculine and five feminine, or vice versâ). The first two or three words of the first verse serve as the burden, and recur in that shape after the eighth and thirteenth verses. There are also double rondeaux and single rondeaux; the latter an obsolete, but easier kind of verse.

Rondo (Ital.). In Music, a light form of composition in which the subject or theme returns frequently. It usually forms the last movement of a symphony or sonata, but is also very common as a separate composition.

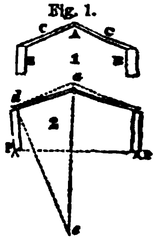
Rood (A.-Sax. rode, *a beam*; used for the cross). The crucifix, with the images of St. Mary and St. John, sometimes also the image of a saint, was so called in English old churches. The place where the rood stood was called the *rood-loft*, which was commonly over or near the passage out of the body of the church into the chancel. They were all ordered to be taken down in 1548 (Burnet, *History of the Reformation*, vol. ii. book i.); but were restored for a short time under Queen Mary. Among the few that escaped the second removal, one of the finest is in the church of Charlton-on-Otmoor, Oxon. The screens dividing the choirs from the naves of most of our cathedrals are old rood-lofts from which the images have been removed.

ROOD. A square measure, the fourth part of a statute acre, and equal to forty perches or square poles.

Roof (A.-Sax. hrof, Gr. ὀροφή). In Architecture, the uppermost part of a building, containing the timber work or the iron work, with its covering of slate, tiles, lead, or other materials. Carpenters, however, restrict their use of the word *roof* to the timber framing alone.

A roof, as regards its construction, involves some knowledge of mathematics, especially since the introduction of ironwork has enabled architects to attempt much greater spans than were formerly thought justifiable. Of the general principles on which the proper construction of a wooden roof depends, we shall here subjoin some account, leaving the construction of iron roofs to be discussed somewhat briefly under STATIONS, RAILWAY.

Fig. 1.



The obvious mode of covering a building where a greater or lesser inclination of the sides of the roof is required by the climate, is to place two sloping rafters C C upon the walls BB, as in the subjoined diagram, meeting at the apex A, where we will suppose them so connected with a hinge, but capable of descending by their own gravity, as shown in No. 2. The walls are considered as solid masses, movable on the points PP. If the

walls be not of sufficient weight, the thrust exerted upon them by the tendency of the rafters to spread at their feet, will throw the walls outwards, as in No. 2, and the whole structure will be destroyed. By the laws of mechanics it is known that the horizontal thrust thus acting upon the wall is proportional to the length of a line *de*, drawn at right angles to the rafter, intersecting a vertical line drawn from the apex, which, it must be evident, must increase as the roof gets flatter. To counteract the thrust above named, nothing more is necessary than to tie together the feet of the rafters as in the following diagram (fig. 2), in which A B is the tie in question, and thence called the *tie-beam*. If the extent be not very great, the rafters may be kept from spreading by a minor tie, at *ab*, called *a collar*.

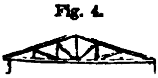
Fig. 2.

Beyond certain lengths, or spans, however, it will occur to the reader that a tie-beam will itself have a tendency to bend, or to *sag* as the workmen call it, in the middle; and from this circumstance a fresh contrivance becomes necessary, which will be seen in the diagram below marked *cd* (fig. 3); this is called a *king post*, or more properly a *king piece*, inasmuch as it does not perform the office of a post, but rather of a tie, for it ties up the beam to prevent its sagging.

Fig. 3.

If the rafters be so long as to be liable to bend, two pieces *aa*, called *struts*, are introduced; which having their footings against the sides of the king posts, act as posts to support or strut up the rafters at their weakest points. The piece of framing thus contrived is altogether called a *truss*, and in the particular case considered it is called a *king truss*. It is obvious that by means of the upper joints of the struts we obtain more points of support for the rafters, or rather points of suspension, and that but for the compressibility of the timber, there would be no limit to the space which a roof might be made to span.

Fig. 4.



This compressibility takes effect where the fibres of the wood are pressed at right angles, or nearly so, with their direction, and many ways are adopted for avoiding this inconvenience. There is a species of roof, dependent in construction on the principles thus described, of which the following is a diagram (fig. 5). Its principles are the same as those already mentioned, and do not here require further notice; this roof has three points of support A B A,

Fig. 5.

the posts A A, A A, are called *queen posts*, the collar A B A is here a *straining piece*, instead of a tie, as it was in the example at first noticed, its operation being, in fact, the exact reverse of a tie. The *curb* or *mansard roof* is one which has the advantage of affording an additional story in the roof, but it requires little illustration from us beyond the drawing subjoined (fig. 6). In the execution of roofs the expense of trussing every pair of rafters would be unnecessary, and the practice would also load the walls with a far greater weight than would be expedient; it is, therefore, the custom to place the principal parts of a roof at certain intervals, which, however, should as a general rule never greatly exceed ten feet.

Fig. 6.

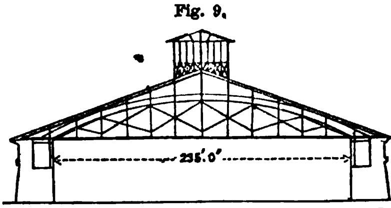
The rafters which are actually trussed are called *principal rafters*, and by the intervention of the *purlin* A in the diagram (fig. 7) they are made to bear the smaller or *common rafters*, which are notched down on to it. These common rafters are received by, or pitch upon, a plate B, called *a pole plate*; and the principal rafters which fall upon the tie-beam are ultimately received upon the wall-plate C.

Fig. 7.

When beams in either roofs or floors are so long that they cannot be procured in one piece, two pieces to form the adequate length are scarfed together, by indenting them at their joints and by bolting them together; of which practice two modes are here represented (fig. 8). It may be of interest to remark that up to the width of span of 40 feet, the practice of architects is to adopt the king post description of roofing; beyond 40, and up to as much as 120 feet, they usually adopt the queen post roofing; but the recent improvements in carpentry, by the adoption of Colonel Emy's principle of forming arches of planks, bent whole, and by Colonel Ardunt's system of polygonal framing, &c., have introduced many new methods of spanning great dimensions. Figs. 9 and 10

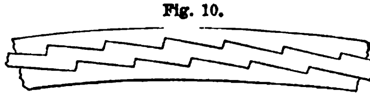
Fig. 8.

Fig. 9.



will show the mode of construction adopted in the remarkable roof of the imperial riding-house at Moscow, built in 1790, the span of which is 235 feet. An arched beam formed in three thicknesses, notched into one another, as shown in fig. 10, is first constructed, and the

Fig. 10.



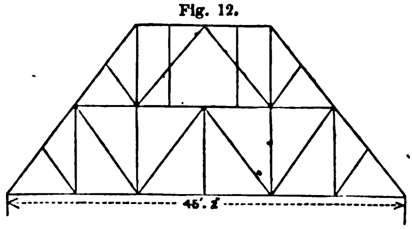
ends of this beam are tied together by a tie-beam running across the chord of the arc, while cross trussing connects the arch and the beam firmly together. Fig. 11 is a representation of Colonel Emy's plank arch as constructed by him, in 1825, for the roof of a building near Bayonne; the principals, wall posts, and arched rib, form two triangles firmly

braced together the whole weight of the roof being thrown at the wall at the feet of the ribs, and not upon the pole-plate. Many, and indeed most, of the modern roofs of large span are now formed of wrought iron. That of the

Fig. 11.

new houses of parliament at Westminster is thus constructed, and the tie-beams and suspension rods are of flat bar iron, the principal and common rafters of T iron, while the struts and purlins are of cast iron, the whole being

Fig. 12.



fitted together with cast-iron shoes. The principle of construction of the roof over the House of Lords is shown in fig. 12.

Rook (A.-Sax. hroc). The name of a well-known species of crow (*Corvus frugilegus*, Linn.), resembling in size and colour the carrion crow, but differing in having the base of the bill whitish and scurfy, and bare of feathers. 'This,' says Montague, 'is acquired by the bird's habit of thrusting its bill into the ground after worms and various insects. The rook derives much of its food from the insect tribe, particularly the larvæ of the cockchafer; and while following the plough to remove from the newly-made furrow this destructive grub, it more than repays the husbandman for the grain which it may afterwards pick up. The rook is gregarious at all seasons, resorting constantly to the same trees every spring to breed, when the nests may be seen crowded one over another upon the upper branches. It lays four or five eggs, much like those of the crow, of a greenish colour, spotted and blotched with dusky. After their young have taken wing, they all forsake their nest-trees, returning to them again in October to roost; but as winter comes on, they generally select more sheltered places at night in some neighbouring wood, to which they fly off together.' (Montague, *Ornithological Dictionary.*) The wood or grove of tall trees, in which rooks congregate and build their nests, is called a *rookery*.

Rook. [Chess.]

Room and Space. In Shipbuilding, the technical expression for the length of the vessel supported by each rib or timber. This varies from 2 feet 6 inches to 3 feet 9 inches, according to the strength required, the weight of the whole structure of the ship being proportioned to the closeness of the timbers together. It is an axiom that the minimum of weight consistent with the requisite firmness, gives the maximum for stowage or speed. The *room and space staff*, called also the *station*, is a marked rod for measuring the room and space on the keel.

Roosts. [Races.]

Root (Dan. rod, Swed. rot). In Arithmetic, a number which, multiplied by itself a stated number of times, is equal to a given number; in other words, the number of which a given number is a stated power. The index of the root is the same as that of the power. Thus the fourth root of 16 is 2, and is denoted by the symbol $\sqrt[4]{16}$. In the most frequently occurring case of square root the index 2 is omitted, and the *radical sign* $\sqrt{\ }$ alone used. [Extraction of Roots.]

The more general and algebraic definition of a root, is any value of an unknown quantity which satisfies a given equation. [Equation.] Thus the ordinary or arithmetical root $\sqrt[n]{a}$ of a number a is merely one of the n roots of the equation

$$x^n - a = 0,$$

a general symbol for which is $(a)^{\frac{1}{n}}$.

The remaining roots are all imaginary when n is odd; and when n is even, one of them is real and negative $-\sqrt[n]{a}$, and the rest imaginary; that is to say, of the form $a + b\sqrt{-1}$, where a and b are real, positive, or negative numbers, all the n roots of a number may be obtained by multiplying its arithmetical n^{th} root into the n *roots of unity*, which latter are easily obtained from *Demoivre's formula*, since $(1)^{\frac{1}{n}} = (\cos\theta + \sqrt{-1}\sin\theta)^{\frac{1}{n}}$ when $\theta = 0$. [Demoivre's Theorem.]

Root. In Vegetable Physiology, that part of the central axis of a plant which is formed by the descending fibres, and whose function is to attract liquid food from the soil in which it is mingled. It differs from the stem in not having leaves or buds upon its surface, and in its tendency to burrow under ground, retreating from light; nevertheless, some kinds of roots

are exclusively formed in air and light, as in the ivy, and other such plants, and also in epiphytes.

Root of Scarcity. One of the names of the Mangold Wurzel.

Roots. In Language, roots are of two kinds, roots demonstrative and roots predicative. The former are properly pronouns; the latter comprise all names, whatever may be the form assumed by them, and express invariably some sensible or material idea. Thus the words *mill* and *meal*, *milk*, *mild*, *immortal*, &c. &c., are traced back to a root, *mar* or *mal*, which expressed originally the sound of crushing or grinding. From this root have sprung words which have apparently nothing in common with each other.

To account for these roots, two theories have been put forward. On the one hand, Prof. Max Müller, adopting substantially the hypothesis of Plato, traced them, in his first series of *Lectures on Language*, to phonetic types, which had a certain congruence and connection with the objects signified. According to this theory, 'each substance has its peculiar ring. We can tell the more or less perfect structure of metals by the answer which they give. Gold rings differently from tin; wood rings differently from stone; and different sounds are produced according to the nature of each percussion. It was the same with man, the most highly organised of Nature's works. Man in his primitive and perfect state was endowed not only, like the brute, with the power of expressing his sensations by interjections, and his perceptions by onomatopœia; he possessed likewise the faculty of giving more articulate expression to the natural conceptions of his mind. That faculty was not of his own making; it was an instinct, an instinct of the mind as irresistible as any other instinct. So far as language is the production of that instinct, it belongs to the realm of nature; man loses his instincts as he ceases to want them. His senses become fainter when, as in the case of scent, they become useless. Thus the creative faculty which gave to each conception, as it thrilled for the first time through the brain, a phonetic expression, became extinct when its object was fulfilled.'

This theory is opposed by those philologists, who maintain the mimetic or onomatopoetic origin of all languages, and who assert that the idea of phonetic types involves a realistic hypothesis in the essential relation of sound to the thing signified by the sound. Professor Max Müller's theory, it is argued, seeks to account for a physical fact by referring it to a metaphysical cause, of the existence of which the alleged effect is the only evidence; the instinct which led man in his primitive state to connect certain sounds with certain ideas, being indicated only by the fact which it professes to explain. Thus, this instinct is an ideal cause set in operation only to satisfy a need of the intellect; and as no one maintains the present operation of this cause, its operation in an earlier stage is a mere metaphysical hypothesis. It is further maintained, that as an imitative origin of certain words is conceded on all hands, the mimetic origin of all language becomes a question relating to the limits of operation of a particular principle, and not to the fact of its existence. Thus it is admitted that such a sound as *pat* may be fairly claimed as imitative; but from this root comes the Greek *πάτος*, and the English *path*, words not specially suggestive of sounds connected with a mimetic root. If, then, this is confessedly the case with some words, why, it is asked, may it not be so with all words? This hypothesis, or rather this statement of facts in certain instances ascertained, is, it is added, the only one that joins the present to the past, while it does not endow our forefathers with instincts of which their children know nothing, the whole burden of the argument being thus thrown on those who impugn this theory. It is further argued that the idea of any relation of sound to the thing signified is a fallacy which has sprung from immemorial association, and that the link forged by imagination has been accepted as existing in nature; that this fallacy is dispelled by the fact of the diversity of languages, which shows that sounds varying indefinitely from each other may be used to express the same notions, and proves that there is no essential connection or congruence between words and things. This argument calls into question the absolute necessity of language, not merely as the vehicle, but as the condition of thought; and while it allows that thought and language are seldom separated in fact, denies that this is never the case, or that the rarity of the fact is anything more than a consequence of human weakness. Finally, it regards the roots or original constituents of language, as mere unmeaning sounds, which attained significance only by being modified to denote objects in which a resemblance may be traced to another object suggested by the original sound, the sum of the whole being that the past is uniform with the present and that the results which the theory of phonetic types traces to an agency now unknown, are due to the mere continuance of causes still everywhere at work. (Max Müller, *Lectures on Language*, first and second series; Farrar, 'Chapters on Language,' *Westminster Rev.* Jan. 1865, July 1866, *Edin. Rev.* Jan. 1862, *Quart. Rev.* April 1866.)

Roots, Primitive. [PRIMITIVE ROOT.]

Roots, Singular. [SINGULAR ROOTS.]

Roots, Squared Differences of. [EQUATION OF SQUARED DIFFERENCES.]

Roots, Symmetric Functions of. [SYMMETRIC FUNCTIONS.]

Roots of Unity. In Algebra, any real or imaginary quantity which multiplied by itself a certain number of times is equal to unity, is termed a *root of unity.* [ROOT.] Owing to the importance of the roots of unity in many algebraical enquiries, we add here a few of their more important properties; for demonstrations, as well as for further details, the

reader may consult any good treatise on the theory of equations. 1. Every positive or negative integral power of an n^{th} root of unity is itself an n^{th} root of unity. 2. Unity itself excepted, no n^{th} root of unity can be at the same time an m^{th} root, when m and n are prime to each other. 3. If n be a prime number and a any n^{th} root of unity (unity itself excepted), the remaining $n-1$ roots will be $a^2, a^3, a^4 \dots a^n$. This property also holds when n is not prime, provided a is a *primitive n^{th} root* of unity, that is to say, provided it is not at the same time a root of unity of a lower order than the n^{th}. 4. The continued product of a p^{th}, q^{th}, r^{th} &c. . . . root of unity is a $(p\,q\,r\dots)^{th}$ root, so that n being a composite number all the n^{th} roots of unity may be formed by the multiplication of roots of a lower order. 5. The sum of all the n^{th} roots of unity vanishes, as does also the sum of their homogeneous products, provided the dimension of each product is less than n. 6. The product of all the n^{th} roots of unity is equal to $(-1)^{n+1}$. 7. The sum of the m^{th} powers of the several n^{th} roots of unity has the value n or 0, according as m is or is not a multiple of n.

Rootstock. [RHIZOME.]

Rope (A.-Sax. rap, Ital. ropa). A certain proportion of fibres of hemp twisted together form a yarn, and a number of yarns form a strand. Three strands twisted together form a rope. The size of the rope depends on the number of yarns contained in it. Rope is either white or tarred, the latter being the best if liable to exposure to wet, the former if not exposed. The strength of tarred rope is, however, only about three-fourths that of white rope, and its loss of strength increases with time. Rope is designated by its circumference, expressed in inches, and is issued in coils of 113 fathoms each; marline and Hambro' line in skeins, spun yarn in pounds: the latter is made from old rope. Government rope is distinguished by a coloured thread, red, blue, or yellow, which runs through it. Rope used in the artillery service is coiled *with the sun*, i.e. from left to right, in which direction the yarns are twisted, so as to avoid *kinking*.

The strength of white hempen rope may be approximately calculated by the following rule, viz.: square the circumference, and divide by five for the number of tons *dead weight* that the rope will bear. But the strain caused by a sharp jerk upon a rope is very much greater than that of a dead weight. The special committee of the Alpine Club reports: 'The strain upon a rope loaded with a weight of fourteen stone, and suddenly checked after a fall of eight feet, is nearly equal to that which is caused by a dead weight of two tons.' [KNOTS.]

Other materials besides hemp are used in the manufacture of rope, but to a smaller extent. Coir rope, which comes from Ceylon and the Maldive Islands, is made from the fibrous husk of the cocoa-nut; Manilla rope from the fibres of a species of wild banana. Wire rope, both iron and steel, is also employed.

Rope-dancer. Among the Greeks the rope-dancer was known by the name σχοινοβάτης, the Latin designation being *funambulus*. The agility of the Roman rope-dancers is illustrated in many paintings discovered in excavations. (Smith, *Dictionary of Antiquities*, s.v. 'Funambulus.')

Rosaceae (Rosa, one of the genera). A large and important Natural Order of perigynous Exogens, the species of which are for the most part inhabitants of the cooler regions of the world. They are in some cases trees, in others shrubs, and in a great number of instances herbaceous perennial plants; scarcely any are annuals. No natural orders contain more species of general interest, in the beauty of their flowers or their perfume. Among the more choice are the Rose itself, and various species of the genera *Rubus*, *Spirea*, *Potentilla*, *Geum*, and *Pyrus*. The Apple, Pear, Plum, Cherry, Peach, Nectarine, Apricot, and similar valuable fruits, are the produce of others. The Whitethorn, with all its numerous exotic allies, belongs to the genus *Crataegus*. As medicinal plants, some are of considerable importance. The root of *Potentilla reptans*, *Geum urbanum*, and others, is powerfully astringent; the bark of *Prunus Cocomilia* has some reputation as a febrifuge; an Abyssinian plant called *Brayera anthelmintica* has energetic vermifugal qualities; and, finally, prussic acid is obtained from the leaves and seeds of the Almond, Peach, Plum, and other related species. This important assemblage of plants is distinguished by having several petals; separate carpels; distinct, perigynous, numerous stamens; alternate leaves, and an exogenous mode of growth.

Rosarium, Rosary. [ROSETUM.]

Rosary (Lat. rosarium, *a rose-bed*). A Roman Catholic devotional practice; which consists in reciting fifteen times the Paternoster, or Lord's Prayer, and 150 times the Ave Maria, or angelical salutation; but as the computation is made by means of beads, the string of beads used for this purpose has acquired the popular name of a rosary. The rosary is thus three times the ordinary chaplet. It is instituted in honour of the fifteen principal mysteries in the life of Christ and of the Virgin Mary. Some have attributed its institution to St. Dominic; others, among whom is Mosheim (cent. x. part ii. c. iv.), give it a higher antiquity. The festival of the Rosary falls on the first Sunday in October. Its name was changed by Gregory XIII. from that of St. Mary of the Victory, given by Pius V. on its original institution in honour of the battle of Lepanto, which took place on that day.

Rose (Lat. rosa. Gr. ῥόδον). In Architecture, the sculptured representation of this flower is found in the centre of each face of the abacus in the Corinthian capital, and is called the rose of that capital. Roses are also used to decorate the caissons in the soffits of coronas and ceilings.

ROSE. In Botany, the English name for

a well-known and universally cultivated flower, belonging to the genus *Rosa*. [ROSACEÆ.]

Rose Engine. In Mechanics, an appendage to the turning lathe, by which a surface of wood or metal, as a watch-case, is engraved with a variety of curved lines. The assemblage of these lines presenting some resemblance to a full-blown rose, is called by the French *rosette*; and hence the engine by which the ornament is produced is called a rose engine. The mechanism by which the figures are produced is composed of one or more plates or cams set on the axis of the turning lathe, or suitably rotated and formed with waving edges or grooves, which govern, in a manner corresponding to the pattern of the edges or grooves, the movement to or from the centre of the cutting point. The combination of the rotatory motion of the lathe and the radial motion of the tool cuts figures corresponding to the nature of the radial motion given.

Rose Quartz. A beautiful variety of Quartz of a rose-red or pink colour, and nearly transparent. Large masses of a most delicate rose colour are to be obtained in the vicinity of Ratnapoora in Ceylon, and it is also found in Aberdeenshire, the Shetlands and Hebrides, near Belfast, Rabenstein in Bavaria, &c.

Roses, White and Red. In English History, the well-known feuds that prevailed between the houses of York and Lancaster are so called, from the emblems adopted by their respective partisans; the adherents of the house of York having the white, those of Lancaster the red rose, as their distinguishing symbol. These wars originated with the descendants of Edward III.; and after extending over a period of more than eighty years of bloodshed and devastation, were finally put an end to by the victory of Henry Tudor, earl of Richmond, over Richard III. in 1485, the victor uniting in his own person the title of Lancaster through his mother, and that of York by his marriage with the daughter of Edward IV. Since that period the rose has been the emblem of England, as the THISTLE and SHAMROCK are respectively the symbols of Scotland and Ireland.

Rose-noble. A gold coin of the value of 6*s.* 8*d.*, first coined in the reign of Edward III.

Roselite. A deep rose-red variety of Cobalt Bloom containing lime. It is met with at Schneeberg in Saxony, and was named after Gustave Rose of Berlin.

Rosellane (Eng. *rose*). An altered Anorthite, according to G. Rose. It is a hydrated silicate of alumina, lime, magnesia and potash, tinged red by manganese, and occurs in small grains embedded in limestone in Sweden and Finland. [ROSITE.]

Roselle. The name given to *Hibiscus Sabdariffa*, the ripened calyces of which have a pleasant acid flavour, and are used both in the East and West Indies for making tarts and jellies, and also a cool refreshing drink.

Rosemary (Lat. ros marinus, *sea-dew*). This name is given to a small evergreen shrub of the Labiate order, which inhabits rocky hills in the neighbourhood of the Mediterranean, and is commonly cultivated in our gardens. It has very narrow green leaves, turned back at the edge, and hoary underneath. The flowers are of a dull greyish blue. It has been employed in infusion as a remedy for headache, and is extensively used in the manufacture of pomatum for promoting the growth of hair. Oil of rosemary gives the green colour to these preparations. It is also said to be one of the ingredients in Eau de Cologne. Narbonne honey is stated to owe its peculiar flavour to bees feeding on the blossoms of the rosemary. The grey bushes, mantled with dewdrops, on the rocky coasts of France and Italy, justify, it is said, the singular name given to the plant. It is the λιβανωτὶς στεφανωματικὴ of Dioscorides.

Rosenite. The name given by Zincken to Plagionite, in compliment to H. Rose, the analytical mineralogist.

Roseola (Lat. roseus, *rosy*). A rash, so called from its rose colour. It is frequently symptomatic of different febrile complaints, of disordered stomach and bowels, of teething, and of any constitutional irritation. Acidulated drinks, mild aperients and sudorifics, and strict attention to the diet, with caution against the application of or exposure to cold, so as to cause a retrocession, are the principal points to be attended to.

Rosetta Stone (so called from Rosetta, a village of Egypt, where it was discovered by the French). The name given to the celebrated stone, now in the British Museum, which has played so distinguished a part in all modern hieroglyphical researches. It is a piece of black basalt, three feet in length, and about two feet and a half in breadth, and contains parts of three different sculptured inscriptions: one in sacred characters, or, as they are termed, *hieroglyphics*; the second in enchorial characters (i. e. in those of the country, or in modified conventional hieroglyphics); and the third in Greek. The inscriptions are a good deal mutilated, particularly the hieroglyphical; but they are still sufficiently distinct to allow the hieroglyphical and enchorial characters to be compared with each other and the Greek. As the discovery of this stone presented to the learned the first opportunity of viewing the Greek in juxtaposition with the Egyptian language, great hopes were entertained that a key would thereby be obtained to the deciphering of the numerous monuments of ancient Egypt. It would appear, however, from the investigations of Dr. Young and Champollion, that the Greek does not faithfully represent the enchorial text, but gives merely its substance. According to the Greek inscription, the stone was erected in the reign of Ptolemy Epiphanes (A. C. 194), whose benevolence it describes, enumerating his victories and the principal political transactions of his reign. (Sir G. C. Lewis, *Astronomy of the Ancients*, p. 387.) [ALPHABET; HIEROGLYPHICS.]

Rosetta Wood. The name of a handsomely veined Indian wood, of hard texture, and a lively orange-red colour, the source of which does not appear to be ascertained.

Rosetum (Lat. *a rose-bed*). A garden or parterre devoted to the cultivation of Roses, of which flower numberless varieties are now found in cultivation, chiefly of the class called Hybrid Perpetuals, a race which combines with great variety and beauty in the blossoms themselves, a habit of flowering successionally through the autumn, which renders them especially valuable for garden purposes. A Rosetum should be laid out formally, with beds either on grass or gravel for the dwarf-habited plants, while standard roses, weeping roses, and pillar or climbing roses are introduced at pleasure to vary the effect.

Rosewood. There are various kinds of Rosewood. That of the Canary Islands, valued for its fragrance, has been already noticed. [RHODORHIZA.] The more important, however, are the valuable South American ornamental timbers so designated, and which appear to be produced by several species of *Dalbergia*. That most esteemed, obtained from Rio Janeiro, is said to be chiefly produced by *D. nigra*; but inferior sorts are probably yielded by *Machærium firmum, incorruptibile*, and *legale*—trees which bear the name of Jacaranda in Brazil; and it is also attributed by Lindley to species of *Triptolemæa*. Some of the species of *Pterocarpus*, again, yield timber so called, African Rosewood being the produce of *P. erinaceus*, and Burmese Rosewood that of *P. indicus*. Some of the Indian Rosewoods are attributed to *Dalbergia latifolia* and *D. sissoides*.

Rosicrucians. A sect of visionary speculators in Germany about the beginning of the seventeenth century. At this time Germany was inundated with tracts, purporting to come from supporters or from enemies of this sect. From one of these, a *Treatise on the Laws of the Rosicrucians*, by Ritter von Maier (1619), we learn that the fraternity had six fundamental laws: 1. That their chief end and object was to cure the sick without fee or reward. 2. That in travelling they were to change their habits and dress, so as to accommodate themselves to those of the countries in which they sojourned. 3. To meet once a year on a certain day and at a certain place, kept secret from the rest of the world. 4. To fill up vacancies in their body by electing fresh members. 5. To use the letters R. C. as their common symbol. 6. That the fraternity should remain undivulged for one hundred years from its foundation. It appears probable that the device of the rose issuing out of the cross, which was the same as Martin Luther's seal, was adopted for the purpose of attracting the notice of the religious: the rose was explained to represent the blood of Christ. It would appear from these laws that some species of secret Freemasonry was intended; and the Rosicrucians have been by some connected with the Freemasons; but there is, in point of fact, no evidence that any such society existed at all. Valentine Andreä, a Lutheran clergyman, is said to have been the original propagator of the reports concerning the Rosicrucian society; and to him is ascribed the treatise, published in 1610, entitled, *The Discovery of the Brotherhood of the Honourable Order of the Rosy Cross*. In this book he merely calls on all who wish to lessen the amount of human ignorance, suffering, and degradation, to come forward and give their names. Owing to the superstitious character of the age, the hoax failed, and the title became a term denoting every kind of occult and magical science. (Hallam, *Literary History*, part iii. ch. iv. § 39.) The Rosicrucians have been connected in various ways, by public opinion, with the Cabalists, Illuminati, &c.; and the division of spiritual beings inferior to the angels into sylphs and gnomes, which furnished Pope with the machinery of the *Rape of the Lock*, is of Rosicrucian or Cabalistic origin. It is found in that singular work by a professed Rosicrucian, the *Comte de Gabalis*, which obtained a sudden popularity in the beginning of the last century.

Rosin. [RESIN.]

Rosin Tin. A miner's name for pale-coloured translucent Tinstone with a resinous lustre.

Rosite. A mineral of a red colour in small grains, embedded in limestone, from Sweden; it appears to be silicate of alumina tinged red by manganese. It has also been called ROSELLANE.

Rosstrevorite. A fibrous variety of Epidote, met with in Ireland at Rosstrevor, county Down.

Rostellate (Lat. rostellum, dim. of rostrum, *a beak*). In Botany, a term applied when any part terminates gradually in a hard long straight point, as the pod of a radish, the capsule of many mosses, &c.

Rostellum (Lat. dim. of rostrum, *a beak*). The name of the mouth of the louse and similar Apterous insects, in which the ordinary trophi are replaced by an exarticulate retractile tube, from which a retractile siphuncle is protruded. The uncinated proboscis of the tape-worms (*Tæniæ*) is also so called.

ROSTELLUM. In Botany, an elevated and rather thickened portion of the stigma of Orchidaceous plants, from which the peculiar gland separates by which the pollen masses of some species of that order are eventually held together. It was formerly supposed to be the point through which impregnation is effected, but this is now known to have been an error.

Roster or **Rollster.** A Military term, implying the seniority list, from which officers are detached for duty in regular succession.

Rostrulum (from Lat. rostrum). In Entomology, the name of the oral instrument of the flea and other *Aphanipterans*; in which the ordinary trophi are replaced by a bivalved beak, between the valves of which there are three lancet-shaped instruments.

Rostrum (Lat. *a beak*). A name applied

metaphorically to the pulpit or pleading-place in the Roman forum, which was decorated with the prows of vessels taken from the enemy.

Rosulate (Lat. rosa, *a rose*). In Botany, this term is applied to those collections of petals or leaves which are packed over each other in many rows, as the blossom of a double rose, the offset of the Houseleek, &c.

Rot (A.-Sax. rotian, *to rot*). A term applied to a well-known disease peculiar to sheep: also termed *cothe*, but more generally known by the term *rot*. Many causes have been assigned for it; as the *Fasciola hepatica* or fluke worm, or some particular plants taken as food; but as most of the supposed deleterious herbs have been tried by way of experiment, and have failed to produce the disease, it must be attributed to some other cause. It is believed that the germs from which the fluke is derived, are taken into the system with the grasses and other green food grown in marshy ground. Bakewell, when his sheep were past service, used to rot them purposely by feeding them on wet land, that they might not pass into other hands. This he always readily did by overflowing his pastures. It is said that land on which water flows, but does not stagnate, will not rot, however moist; but this is contradicted by the experience of Bakewell, who used merely to flood his lands a few times only to rot his sheep. It is also said that they are safe from rot on Irish bogs, salt marshes, and spring-flooded meadows, a statement apparently verified by experience. When salt marshes are found injurious, it is only in years when the rain has saturated or rather super-saturated such marshes. The assertion that putrid exhalations unaccompanied with moisture can occasion rot, needs confirmation; for these commonly go together, and it is difficult to separate their effects. It is not the quantity of water immediately received by land, but the capacity of that land to retain the moisture, which makes it good breeding ground for the germs of the disease, and thus makes the land itself of a rotting quality.

The signs of rottenness are sufficiently familiar to persons about sheep. They first lose flesh, and what remains is flabby and pale; they also lose their vivacity. The naked parts, as the lips, tongue, &c., look livid, and are alternately hot and cold in the advanced stages. The eyes look sad and glassy, the breath is fœtid, the urine small in quantity and high-coloured; and the bowels are at one time costive, and at another affected with a black purging. The wool will come off on the slightest pull in almost all cases. The disease has different degrees of rapidity, but is always fatal at last. This difference in degree occasions some rotted sheep to thrive well under its progress to a certain stage, when they suddenly fall off, and the disease pursues the same course as with the rest. Some graziers know this crisis of declension, as it has been called, and kill their sheep for market in the immediate nick of time with no loss. In these cases, no signs of the disease are to be traced by ordinary inspectors; but the existence of the flukes, and still more a certain state of liver and of its secretions, are characteristic marks to the wary and experienced.

The treatment of rot is seldom successful, unless when it is early commenced, or when the disease is of a mild nature. A total change of food is the first indication, and of that to a dry wholesome kind: all the farinæ are good, as the meals of wheat, barley, oats, peas, beans, &c. Oilcake is good also. Carrots have done good, mixed with these: broom, burnet, elder, and melilot, as diuretics, have also been recommended; but it is necessary to remark, that there is seldom any ventral effusion but in the latter stages of the complaint. As long as the liver is not disorganised, a cure may be looked for by a simple removal of the cause, aided by such remedies as assist the action of the biliary system. Salt acts in this way, and thus salt mashes are good: salt may also be given in the trough, to be licked at will by the sheep.

Rot. In timber. [Dry Rot.]

Rota (Ital.). An ecclesiastical court at Rome, consisting of twelve prelates. It takes cognisance of all suits by appeal, and of all matters, beneficiary and patrimonial.

Rotation (Lat. rotatio, from rota, *a wheel*). In Mechanics, the motion of a solid body about an axis. In the article Pendulum, the rotation of a body under the action of accelerating forces has already been considered. In that article reference was made to the purely kinematical part of the question, and it was shown how rotations can be combined and resolved. It will be sufficient here, therefore, to add a few words with respect to the dynamical part of the subject, and to consider briefly, 1. The rotation of a body about a fixed axis produced by any instantaneous forces; 2. The effect of such forces when only one point of the body is fixed; and 3. Their effect on a body free to move in any direction whatever. In doing so we shall merely transcribe the more important results developed with such marvellous perspicuity by Poinsot in his *Théorie Nouvelle de la Rotation des Corps*, Paris 1852.

1. The instantaneous forces acting on the body capable of rotating around a fixed axis oz may always be resolved into a single force R, passing through o and inclined at an angle a to oz, and a single couple G, whose axis, which we may suppose also to pass through o, is inclined at an angle ϕ to the axis of rotation. The latter, therefore, will receive two percussions, one R cos a in the direction of its length, the other R sin a perpendicular thereto. These will be sustained by the fixed supports, and will be without effect on the subsequent rotation of the body, as will also the component G sin ϕ of the couple, the plane of which contains the axis. The only effective part of the forces, therefore, will be the component couple G cos ϕ, acting in a plane perpendicular to the axis; it

will cause the body to rotate with an angular velocity θ equal to the quotient of its own moment, G cos ϕ, by the moment of inertia $\int r^2 dm$ with respect to the axis of rotation. Unless the latter, however, be a central principal axis, a momentary percussion will be produced on it by this *couple of impulsion* G cos ϕ itself; this percussion will be due to a force

$$P' = -\theta\sqrt{(\int x\,dm)^2 + (\int y\,dm)^2},$$

applied at o perpendicularly to the axis, and vanishing only when the latter passes through the centre of gravity, and to a couple whose plane contains the axis and whose moment is expressed by

$$K' = -\theta\sqrt{(\int xz\,dm)^2 + (\int yz\,dm)^2}$$

and consequently vanishes only when the axis of rotation is a principal axis of the body. These several percussions being destroyed by the fixed axis, the body will commence its rotation around the latter *freely*, as around a *spontaneous* axis, and by so doing give rise to centrifugal forces which, unless the axis be a central principal axis, will produce a permanent strain upon it during the whole course of the motion. The components of the strain are a force $-P'\theta$, perpendicular to the axis through o, whose line of action turns with the body, and a couple $-K'\theta$ acting in a plane which turns with the body and passes through the fixed axis.

2. The effect of instantaneous forces on a body capable of moving about a fixed point o is somewhat more complicated. Such forces may always be resolved into a single one acting at o, and therefore destroyed, and to a single *couple of impulsion* whose plane, or one parallel to it, is called the *invariable plane*, from the fact that if, at any period of the body's motion, the forces which animate its several particles be resolved, the same couple of impulsion will be obtained.

To form a conception of the motion of the body, let the Momental Ellipsoid corresponding to the point o be constructed. The instantaneous axis of rotation will pierce this ellipsoid in a point I, the *instantaneous pole*, at which the tangent plane is parallel to the invariable plane. If this tangent plane be fixed and the ellipsoid be made to roll on it without sliding, so as to carry with it the whole body, the motion of the latter will be precisely imitated, at least so far as the successive positions in space are concerned. To render the representation dynamically perfect, it is only necessary to make the ellipsoid roll so that the angular velocity about the instantaneous axis o I shall be proportional to the length of the latter. The locus of the pole I on the ellipsoid is called the Polhode; and the curve which it traces on the fixed plane, the Herpolhode.

Euler's equations of the motion of a body around a fixed point may now be easily interpreted. If A, B, C, be the principal moments of inertia, and, at the instant under consideration, p, q, r, be the resolved parts, along the principal axes, of the angular velocity about the instantaneous axis, these equations are:

$$A\frac{dp}{dt} = (B - C)\,qr,\quad B\frac{dq}{dt} = (C - A)\,rp,$$

$$C\frac{dr}{dt} = (A - B)\,pq.$$

(Euler's *Theoria Motus Corporum Solidorum*, 1765.)

3. The effect of instantaneous forces on a perfectly free body may now be easily conceived. Such forces are equivalent to a single force, applied at the centre of gravity, which imparts to the whole body a purely translatory motion, and to a single couple whose effect has been already described.

4. The equations of the motion of a body about a fixed point under the action of accelerating forces are—

$$A\frac{dp}{dt} - (B - C)\,qr = L,$$

$$B\frac{dq}{dt} - (C - A)\,rp = M,$$

$$C\frac{dr}{dt} - (A - B)\,pq = N,$$

where L, M, N are the moments, relative to the principal axis, of the impressed forces acting at the instant under consideration. To these equations must be added three others, which define the positions, relative to axes fixed in space, of the principal axis of the body at the time under consideration. Except in a few special cases these equations have not been integrated. (Poisson's *Mécanique*; Price's *Infinitesimal Calculus*, vol. iv. &c.)

Rotation of Crops. In Agriculture and Gardening, it is found that the same annual crop cannot be advantageously cultivated on the same soil for more than one or two years; and hence one kind of crop is made to succeed another. The number of cultivated crops being limited, when the whole course has been gone through once, the series is again repeated; and hence the use of the word *rotation*. As the same kinds of crops are not, however, always grown in regular succession, a change being frequently made according to general principles, the term used in that case is *succession of crops*. The principle on which the succession of crops is founded is, that every kind of plant extracts nourishment from the soil, and leaves it deficient of that which should prove nutritious to another species. As a general principle of guidance in determining the succession of crops, it is considered advantageous that a crop cultivated for its leaves or roots should succeed one cultivated for its ripened seeds; that the cereal grasses should be succeeded by leguminous plants; taprooted plants, or plants bearing tubers, by fibrous-rooted plants; plants which form a compact covering on the surface, such as corn and legumes sown

broadcast, by plants which only partially cover the surface, such as crops grown in rows sufficiently wide to admit of cultivation between; and plants which may be said by their abundant leaf to feed the soil with what they take from the air, by plants which are almost wholly dependent upon the stores of food for them contained in the soil and subsoil. It may also be adopted as a rule, that where land is to be subjected to a crop of the same plants for a number of years, as in permanent pasture, the plants composing the crop should be of several different kinds, seeking a different kind of aliment. Hence the propriety of sowing clover, ribwort, and other taprooted dicotyledonous herbage plants among pasture grasses.

Rotations, Composition and Resolution of. In Kinematics, the transformation of a given system of rotations to another equivalent system. A rotation, like a force, may be represented perfectly by a right line of definite direction and length. The direction must coincide with that of the rotation-axis, and the length be made proportional to the angular velocity. Poinsot has shown (*Théorie de la Rotation des Corps*) that these line-representatives of rotations may be combined according to precisely the same laws as those of forces. [FORCES.] Thus the resultant of any number of coaxal rotations has the same rotation-axis as the components, and an angular velocity equal to the algebraical sum of the angular velocities of the components; and again, the diagonal of a parallelogram represents, fully, the resultant of the rotations similarly represented by its two conterminous sides. Further, two equal and opposite rotations around parallel axes constitute a *couple of rotations*, and are equivalent to a translation of the whole body perpendicular to the plane of the couple, with a velocity equal to its *moment*, i.e. to the product of either of the equal angular velocities into the *arm of the couple* or distance between the parallel axes. [COUPLE OF ROTATIONS.] This being the case, we are led to the following important results. Every system of rotations impressed upon a body is equivalent to a single rotation around an axis passing through any point o, and to a translation of the whole body in a direction inclined to that axis. The magnitude R of this resultant rotation as well as the direction of its axis are invariable, but the magnitude and direction of the translation vary in general with the position of the assumed origin o. By removing the point o to a certain point A in the line oA perpendicular to the above axes of translation and rotation such that $oA = \frac{G \sin \phi}{R}$, where ϕ is the angle between the two axes, the whole system is reduced to a rotation R around a parallel axis through A, and a translation in the direction of this axis whose velocity is expressed by $G \cos \phi$. This new axis is called, as before [FORCES, COMPOSITION AND RESOLUTION OF], the *central axis*; or when the motion of the body at the moment is considered, the *instantaneous sliding axis*, since at that moment the motion in question may be regarded as composed of a rotation about the axis along which the body simultaneously slides; in short, as a screw-like motion. The given system of rotations may also be reduced to two rotations around axes which do not intersect, and that in an infinite variety of ways. Any two such axes are called *reciprocal* or *conjugate lines*, and possess remarkable properties, for a full statement of which the reader must be referred to the investigations of Poinsot, Chasles, Lamarle, and others. [KINEMATICS.] The line upon which the shortest distance between two conjugate lines is measured always meets the central axis perpendicularly, and there are innumerable conjugate axes at right angles to each other.

In order that a body may remain in equilibrium under any system of impressed rotations, the resultant rotation and translation R and G at every point o must each vanish. If R alone vanish, the whole motion will resolve itself into one of translation. If the body have a fixed point o, its motion will consist of a rotation around an axis through that point whose position in the body as well as in space will vary every instant. Such an axis is called an *instantaneous axis*, and the clearest image of the body's motion is obtained by conceiving a cone, attached to the body, to roll upon another cone fixed in space; both cones having the fixed point o for vertex. The common generator of the two cones at any moment is the instantaneous axis of the body.

Rotatories. Wheel animalcules. [ROTIFERS.]

Rothoffite. A variety of common iron-Garnet from Längsbanshytta in Sweden, containing a large quantity of protoxide of manganese.

Rotifera (Lat. rota, *a wheel*, and fero, *I carry*). The name of a class of highly organised Infusorial animals, of the articulate type, outwardly distinguished by certain ciliated appendages at the anterior part of the body, which seem to move in a rapid rotatory manner, and by their superior size. They are commonly termed *wheel animalcules*.

Rotten Stone or **Tripoli.** The name given to certain natural earths, consisting of silica in an extremely fine state of division, and in a state adapted to polish without scratching the surface of glass, metals, &c. These vary greatly; chiefly, however, in the mechanical state in which the silica exists. *Trent sand* or *wharpe*, a river sand used for bringing German silver and other alloys to a surface, is a sharp sand obtained from the river Trent, and consists chiefly of infusorial animalcules. Bath brick is nearly the same in its origin. The *polir schiefer* of Germany and the powder from Bilin are also of the same kind. There is in these an admixture of carbon, and occasionally a little resinous organic matter. *Rotten stone*, either Welsh or from Derbyshire (near Bakewell), is a lighter and more friable

material of very fine grain, and is now used for silver and the finer class of goods. It is found among the carboniferous limestone in seams between two masses of limestone, and of small thickness. *Tripoli* is the name applied to the earthy varieties in which the silica is nearly pure and the particles very minute. Lime is sometimes used instead of the silica powder, and powdered hæmatite or some other form of peroxide of iron is the chief polishing material used in glass-making, but the true rotten stone is always silicious, and consists of silica in an extremely minute state of division, whether derived from the animal, vegetable, or mineral kingdom.

Rottlera (after Dr. Rottler, a Dutch missionary and naturalist). A genus of small Euphorbiaceous trees found in tropical Asia and Australia. The most interesting is *R. tinctoria*, a common Indian bush, from the surface of whose capsules, which are about the size of peas, a red mealy powder is obtained, well known in India as Kámalá, and much used by Hindu silk-dyers, who obtain from it, according to Roxburgh, a deep bright durable orange or flame colour of great beauty. This is obtained by boiling the powder in a solution of carbonate of soda. The root of the tree is also said to be used in dyeing. The Kámalá appears also, according to Mr. Hanbury, to be used in cutaneous complaints. Among the Arabs of Aden it is given internally in leprosy, and used in solution to remove freckles and pustules; in this country it has been used successfully in treating the eruption known as wildfire on children, by rubbing the powder over the affected part with moist lint. It appears, however, to be most valued as an anthelmintic, and has been extensively used with much success in India by various medical men, in cases of tapeworm.

Roturier. In French History, the political antithesis to the noble. Not only were the nobles invested with certain personal immunities and privileges in France, but they were relieved of the *taille*, an oppressive property tax, which fell on the lower classes exclusively. The wrongs inflicted on the roturier or peasant were described by Arthur Young; and it cannot be doubted that the remembrance of these wrongs increased, if indeed it did not originate, the bitterness of parties during the revolutionary era. The name *roturier* is very ancient, and was early used in a contemptuous sense. (Hallam, *Middle Ages*, chap. ii. part ii.)

Rouble (Russ. rublyn). A Russian silver coin of different values. It was first struck at Moscow in 1654. Catherine II. caused some gold coins to be struck with this name; but they are no longer current. The silver standard has been established since 1839 as the lawful money of account and exchange in Russia, and is valued at par at a little over 3*s.* 1½*d.* There is, however, a paper rouble called *banco*, which circulates at two-sevenths of the silver rouble. Hence the banco rouble is equal to 10⅝*d.* sterling. For a valuable account of the Russian paper money, see Tooke's *History of Prices*, vol. iv. pp. 209 sqq. [MONEY.]

Roué (Fr. literally *one broken on the wheel*, the punishment of the highest crimes in France before the Revolution). In the beau monde, a person devoted to a life of pleasure and sensuality, but not so completely vitiated in his character and manners as to be excluded from society. The term is said to have been first used in this sense by Philip of Orleans, the regent of France.

Rouge (Fr.). A species of lake prepared from the dried flowers of the *Carthamus tinctorius*, or safflower. The term *rouge* is also applied to finely levigated *colcothar*, or peroxide of iron, used for polishing.

Rough Cast. In Architecture, the plastering of walls with mortar and fine gravel, or when the rendering coat is roughened by means of a stiff broom, without any subsequent rendering to produce a smooth surface.

Rough Coal. A name for SPLINT COAL.

Rough Stucco. In Architecture, stucco floated and trowelled in a small degree with water.

Rough-tree Rail. In a ship, the horizontal timber or plank forming the top of the bulwarks. It rests on the heads of the several ribs or timbers, and at the same time caps both the external and internal planking.

Roughing In. [RENDERED AND SET.]

Roulette (Fr.). The curve traced by any point in the plane of a given curve when the latter rolls, without sliding, over another fixed curve. A similar definition applies to surfaces. Roulettes include a great number of well-known curves, amongst which are epitrochoids, hypotrochoids, epicycloids, hypocycloids, the common and curtate cycloids, involutes, &c. Pedal curves may also be regarded as roulettes. In fact, if the fixed and rolling curves were precisely equal and, without coinciding, touched each other at corresponding points, any point in the plane of the rolling curve would describe a curve similar to the pedal of the fixed curve with respect to the corresponding point in its plane. An interesting memoir on roulettes by Prof. Maxwell will be found in the *Cambridge Phil. Trans.* for 1849. The normal, and consequently also the tangent at any point of a roulette can be easily constructed. In fact, at any instant the rolling curve may be considered as rotating around its point of contact with the fixed one, so that the element at a point m of the roulette must be perpendicular to the line $o\,m$, in other words $o\,m$ is the normal at m. The radius of curvature ρ of the roulette at m can also be found by very simple considerations. If ρ_1 and ρ' denote the radii of curvature of the fixed and rolling curves at their point of contact o, then,

$$\frac{om}{\rho} = 1 - \frac{\cos\phi}{\frac{om}{\rho_1} + \frac{on}{\rho'}}$$

where ϕ is the angle between the normals to the roulette and to the fixed curve. (Liouville's *Journal*, t. x.) Mr. Stubbs, in vol. i. *Trans. Dublin Phil. Soc.*, has given a general method of finding the area of a roulette.

Round (Fr. rond, Lat. rotundus). The property of a circle, sphere, or right cylinder, and indeed of any solid of revolution, though most commonly confined to the sphere and cylinder. French writers term all bodies enclosed by surfaces of revolution *corps ronds*.

Round Robin (Fr. rond ruban). A phrase originally derived from a custom of the French officers, who on signing a remonstrance to their superiors wrote their names in a circular form, so that it might be impossible to ascertain who had headed the list. It is now used to signify any act by which a number of men bind themselves to pursue a certain line of conduct.

Round Shot. In Artillery, spheres of cast iron or steel.

Round Table of King Arthur, The. According to the legendary accounts, this mythical sovereign instituted a company of twenty-four (or according to others twelve) of his principal knights, bound on certain solemn days to appear at his court, and meet round the table whence their common title was derived. The famous table (of unknown date, but comparatively very modern) still to be seen in the shire hall at Winchester illustrates this celebrated fiction. The rhyming chronicle *Brut of England*, composed or continued by Master Wace (A. D. 1155), is considered by antiquaries as the source whence the popular romances concerning Arthur and his knights were first derived. The myths of King Arthur are given gravely as history in the chronicle of Jeffrey of Monmouth. (*The Romance of Sir Tristram*, edited by Sir Walter Scott; Milman, *History of Latin Christianity*, book xiv. ch. vi.; Lappenberg, *England under the Anglo-Saxon Kings* i. 101.) [Roland; Sigurdr.]

Roundel. In Heraldry, an ordinary in the form of a circle. It is improper to say a roundel or, gules, &c., describing it by its tincture; unless, first, in case of counter-changes; secondly, where the roundel is of fur, or of equal tinctures, as a roundel ermine, a roundel checky of or and azure, &c.; otherwise, roundels have distinguishing names, according to their tinctures. A roundel or is called a *bezant*, from the gold coins of the Greek or Byzantine empire; a roundel argent, *a plate*; gules, a *torteau*, a kind of cake; azure, *hurt*, a species of flower; vert, *pomme*; sable, *pellet*; purpure, *golpe*. A field or charge, with equidistant roundels, is said to be *bezanty*, *platy*, &c., according to the tincture.

Roundelay. In Poetry. [Rondeau.]

Roundheads. A nickname given to the Puritans, at the time of the civil wars, by the Cavaliers, from the close black skull-cap, reaching down to the ears, which was then worn by staid and serious persons; or, more probably, from their custom of wearing the hair closely cut to the head.

Roup. A Scotticism for *auction*.

Rout. [Riot.]

Route (Fr. feuille de route). In Military language, the document conveying to troops an order to move from one place to another.

Route, Commercial. It seldom happens that any one country possesses such an area, with such a variety of soil, of climate, of mineral wealth, of geological formations, as will enable it to supply itself with all the conveniences of life within its own boundaries. However various may be its products, however copious its resources, it can very rarely make itself independent of the rest of the world (if indeed it ever could do so) without inducing not only great moral and political inconveniences, but great economical loss. Some countries approximate to this condition, or have been isolated for reasons chiefly political. Thus, perhaps, up to the middle of the thirteenth century, there was little or no communication between China and the rest of the world, the resources of that vast country enabling it to subsist, and develope a peculiar kind of civilisation, apart from any intercourse with the rest of mankind. Thus, also, it appears that the monarchies of Mexico and Peru, discovered by the Spanish navigators, lived in absolute insulation. Till within late years, the intercourse of the Japanese with any other country was almost prohibited. In all these cases, however, though a considerable developement of economical arts has been achieved, the social condition has been lower and the conveniences possessed by the people far below those which might have been procured by intercourse with other nations.

The agencies of foreign trade have been induced by two causes. Communities, from the want either of certain utilities or objects of enjoyment, which could not be produced in the area of their own country, have been eager to procure these benefits, by acts of exchange, from other countries in which they were plentifully produced, or they have made themselves the carriers between nations and distributed the products of one in exchange for the products of another. Both these operations were exhibited in the history of ancient commerce. The Greeks, it seems, produced in order to exchange. Athens, for instance, had mines and manufactories, and exchanged the articles which she produced, against the grain and other raw material of the regions which lay near the rivers and on the east of the Black Sea; while Carthage, like the rest of the Semitic colonies, was chiefly engaged in the carrying trade, between the remotest East and West on the one hand, and the area of the Mediterranean on the other.

Among these ancient commercial routes, one of the earliest is that by which the produce of the farthest East was conveyed by coasting along the southern coast of Asia to the ancient ports of the Red Sea. By this, and probably by an overland route as well, the exotic treasures and curiosities which Solomon gathered,

were imported into Palestine. Similarly, it is clear that the ethnological notices contained in the history of Herodotus were obtained from and indicate the march of caravans, by the northern route of the plateau of Central Asia, over the Caucasus to the ports of the Black Sea, by the Danube to the western extremity of Gaul, perhaps of Spain, as well as through the tribes which occupied the territory lying below the southern shore of the Mediterranean. Intercourse with the Eastern world was, however, checked rather than developed by the growth of the Roman empire, and it is probable that at or about the commencement of our era, commerce with the East was narrower than in the days of Herodotus, still less than that in the time of Alexander. Rome destroyed Carthage, but did not inherit her spirit of commercial enterprise.

After the irruption of the barbarians, and the downfall of the Western Empire, the commerce of Christendom with the East passed chiefly through Constantinople, the communication between the Mohammedan kingdoms being occasionally regular, though more frequently interrupted. A new era commenced with the injury inflicted on the empire of the East by the Latin conquest, and the rise of the commercial republics of Italy. These commercial republics, such as Venice, Genoa, and Florence, owed some of their riches to manufacture, but more to the carrying trade; and very exact information, considering the times, may be obtained as to the course of traffic. Towards the close of the thirteenth century, Marco Polo published his travels, in which he recounts his observations, in the course of his journeyings from Venice to the extreme verge of Eastern China. But the best accounts given of the trade of Venice and Florence, in the beginning of the fourteenth century, are found in the works of Sanuto and Balducci, the former a Venetian, the latter a Florentine.

Marino Sanuto Torcellus was a Venetian senator, who composed a work in the year 1321 (entitled *Secreta Fidelium Crucis*, and printed in a collection of historical documents, under the name of *Gesta Dei per Francos*), addressing his statements to Pope John XXI. The immediate purpose of this work is to insist on the danger which menaced Europe from the great power of the sultan of Egypt, and to point out the means, partly commercial, partly military, by which the danger might be averted. In explanation of his plan, he gives a statement of the routes by which Eastern produce was imported into Europe.

This produce was collected at two ports, Malabar and Cambeth, the latter being probably Ceylon, and thence shipped to four other ports, Hormus, Kis, the river below Baldac (i.e. Bagdad), and Aden. The earlier, and, to judge from the price of commodities, the cheaper route, was that from Bagdad up the Tigris, and through Azerbijan to Seleucia, then called Licia, and Antioch. But this road had been interrupted or rendered unsafe by the political events which have ultimately reduced the most fertile and once most prosperous parts of Central Asia to a desert. The chief course lay by Aden, up the Red Sea, across the eastern desert of Egypt, to Chus on the Nile, and thence to Alexandria. Sanuto's plan among other details suggests that an ancient route through Armenia to Trebizond might be restored. This route Sanuto informs us that he had traversed five times in person. It is singular that there seems to have been more easy access to mid-Asia in that time than there is now. This Christian merchant visited, apparently with no extraordinary risk, certainly with the means of successful traffic, regions which cannot be entered now, except in the most cautious manner. How dangerous it is to enter Bokhara, which was passed by Sanuto, may be seen from the travels of Wolff and Vambéry.

Balducci refers to another road, lying to the north of those specified by Sanuto, which passed from China to the Caspian, and thence by the Don to the Black Sea. Some of these caravans were, no doubt, directed to Novgorod and Moscow.

Distinct, but contemporaneous with this trade to Egypt, was that carried on by the Hanseatic League, the origin and history of which have been commented on by the learned and laborious Lappenberg. This famous league, founded for mutual defence, and equally important for the purpose of establishing a uniform mercantile system, drew to itself nearly all the trade of North-eastern Europe, and actually established communications with North America. This intercourse came to a violent end, in the great physical events which accompanied the plague of 1348, the effect of which was to raise a barrier of ice round Greenland, and to make intercourse with Iceland difficult and dangerous. It is probable that other commercial routes existed, but these were by far the most important.

The stimulant of the caravan and Red Sea trade was the demand for spices, the craving for which among the Western nations was the more urgent, as the imperfect agriculture of the time made the winter diet of our forefathers unpalatable and unwholesome. The cost of these articles was very great; pepper, the commonest of them, being worth in England, on the lowest estimate of ancient money, not less than 8*s.* the pound troy before the great plague, and double that price afterwards. According to the *Forme of Cury* (a treatise on cookery written in the reign of Richard II. by or for the king's cooks), pepper, as in the story of the *Arabian Nights*, was used in confectionery.

The exchange was effected by metals, and particularly by silver. From the remotest ages, India and China have absorbed the metallic produce of the Western world. Mines in these regions have either been scanty, or have not been worked successfully. The necessity of exporting silver to the East in exchange for its produce first broke down that ancient

commercial superstition, that the wealth of a country consists in the gold and silver which it possesses. That India has not been flooded with silver, in spite of this continuous importation, is due to bad government, which, compelling the people to resort to hoarding, has indirectly, by a reverse process to that of mining, consigned again to the earth the treasure which labour in other regions had collected and transported to the Indian peninsula.

It is hardly necessary to say, that the political greatness of Italy during the middle ages was due to the monopoly of the carrying trade. The almost simultaneous discovery of the American continent in 1492, and of the Cape passage in 1497, by Columbus and Vasco de Gama, completely altered the relations in which Italy stood to Europe, by drying up the channels through which Eastern wealth had previously flowed. For a while the great republics of Venice and Genoa lived on the past—lived, as economists might say, on their capital; and so enduring was the recollection of their former commercial greatness, that it fell utterly only at the first shock of the revolutionary army of France.

Meanwhile, there was a short period during which Portugal took a great place in the commercial world. For a while it seemed possible that the victories of Albuquerque, and the preaching of Francis Xavier, might create a lasting empire. But this strange mixture of commercial enterprise and religious fanaticism was radically weak when it seemed strongest, and the long sea passage was slowly appropriated by the Dutch and the English.

The discovery of the New World was followed by the Spanish conquests. The vast empire which the Spanish monarch administered in the sixteenth century, overshadowed and dismayed the rest of Europe. But the occupation of Mexico, and much of the southern continent, was from the beginning not commerce, but rapine. After destroying the ancient monarchies of the New World, and pillaging their treasuries, the Spaniards exterminated the ancient inhabitants by compulsory labour in the mines, and at the instance of Las Casas, who saw in such an expedient the only means of saving the relics of the ancient races, introduced negro slavery into America. In order, however, to bind their colonies more closely to Spain, and secure their dependence, it was the settled policy of the court of Madrid, that no person of Indian or mixed blood, and not even anyone of pure Spanish descent, born in the New World, should be occupied in any public office. (Lecky, *Rise and Influence of Rationalism in Europe*, ch. vi.)

It was impossible that from such a system any true commercial energy should be developed. It was unlikely, after these colonies were emancipated, that they should emerge from so long a political nonage into the possession of such faculties as are needed for the social advancement of communities. The resources of the New World were wasted by the Spanish occupation. But if the economy of the Spanish colonies had been ever so prudent, it may be doubted whether, in the face of the political events which occurred in Spain at and after the commencement of the sixteenth century, events whose effect became yearly more destructive to the national character, the necessary spirit of commercial enterprise could have survived the utter annihilation of religious and civil liberty. Anyone who compares the constitution enjoyed both by Castile and Aragon in the middle ages with the tyranny of Charles and Philip, can see sufficient reason to account for the decline of Spain. Not but that its strength survived its wealth and real prosperity. Impoverished as it was by the resistance of the Netherlands, the final blow to the ascendency of Spain was given in Van Tromp's defeat of the Spanish Armada in the year 1639. Long before this date, however, the Dutch had crippled Spain in her Transatlantic and Asiatic settlements; and though the English government was unfriendly to the Dutch, it was a general principle that there was no peace with Spain beyond the line.

It would be impossible within the limits of this article to give any exact account of the various commercial routes in our own day. The reader may be referred to Maury's *Physical Geography of the Sea* for much valuable information as to the effect of those discoveries which navigators have made on the course of trade. One of these discoveries may be adverted to. In 1775, Franklin found out the nature and course of the Gulf Stream, but for political reasons kept the fact a secret till after the acknowledgement of American independence. There was great reason for this secrecy, since, if the real effect of the discovery had been known, it is probable that the Southern states of the American Union would not have exhibited so much sympathy with the national cause. Before the time in which the knowledge of this current was possessed, the northern ports of the American plantations were inaccessible in the winter months, and the chief port was Charleston. But after the nature of the Gulf Stream was known, the greater part of the trade was diverted to the northern ports, and New York and Philadelphia became the chief cities of the Union.

It will be a singular circumstance, if in our day the dream of the Pharaohs and Ptolemies should be realised, the Red Sea and the Suez canal again become the highway for Eastern trade, and those parts of the Mediterranean whose greatness has passed away by the use of the long sea passage be again revived as centres of commercial activity.

Rowan-tree (Norse runa, *a charm*). A Scottish name for the *Pyrus Aucuparia*. 'The most approved charm against cantraps and spells,' says Jamieson, 'was a branch of the Rowan-tree planted and placed over the byre. This sacred tree cannot be removed by unholy fingers.' Johnston also observes,

'Roan-tree and red thread
Haud the witches a' in dread.'

Rûn-stafas were mysterious staves; and from this last use of the word, the name *rûn* came naturally to be applied to the tree from which such staves were usually cut, though why this tree should have been so exclusively used for carving runes upon as to have thence derived its name, not only in Britain, but also in Scandinavia, does not appear to be ascertained. (Prior, *Popular Names of British Plants.*)

Rowing. The propulsion of a boat by oars. Rowing is reckoned the most favourable application of human strength for obtaining motion in the water; but the whole force is not effective on the oar, as the part of the oar's blade in the water, but inside the actual fulcrum, which is at its point, is held back by the resistance of the fluid. In rowing, the power is applied at the handle of the oar, and the weight of the boat is encountered at the rowlock. The rower sits *before* his oar, with his back to the boat's bow, and in taking his stroke supplements the strength of his arm with the weight of his body thrown backwards towards the bow. Some nations take short strokes, which they rise up in making; the English prefer a long stroke sitting.

ROWING. In the service of ordnance, the same as *pinching*. [PINCHING.]

Rowlock. The apparatus on the side of a boat for keeping the pressure of the oar constantly at one point. In different parts of England various devices are practised for this end. At sea, the commonest plan is to have two short wooden uprights projecting from the gunwale, between which the oar is restrained. On the Thames these are aided by a button on the oar, to prevent too great a length passing overboard. On the south coast an iron stirrup sustains the oar and pivots in the gunwale. On the east coast of England an iron pin is fixed in the gunwale, and the oar fastened to it by a leathern thong. In the north-west counties a similar pin passes through the oar itself, which precludes feathering altogether. The last two systems are dangerous, from the impossibility of shipping the oars in case of sudden emergency; while, on the other hand, they lessen the probability of losing them.

Roxburghiaceæ (Roxburghia, the only genus). A small natural order of Dictyogens, distinguished by having bisexual flowers, and solitary simple many-seeded carpels, with long-stalked anatropal seeds, and a basal placenta. The few species referred to the genus *Roxburghia*, which constitute this group, are chiefly of botanical interest.

Royal. In Naval affairs, the sail and mast above the top-gallant sail and top-gallant mast respectively.

Royal Oak. *Robur Carolinum.* In Astronomy, a constellation formed by Halley, in the southern hemisphere. [CONSTELLATION.]

Ruay. The name given to certain weights used in India, consisting of the seeds of *Abrus precatorius* and *Adenanthera pavonina*, the former being called Small Ruay, and the latter Large Ruay weights.

Rubace or Rubasse. Names given by French lapidaries and jewellers to a variety of Rock Crystal traversed by rose-coloured cracks. For further details, see Bristow's *Glossary of Mineralogy*, p. 324.

Rubble. A quarryman's term for the inferior varieties of stone surmounting each valuable bed of limestone extracted for building purposes. It is often the result of weathering or natural disintegration by air and water, sun and frost. The fragmentary masses often found between a rock and the overlying soil derived from the rock, are also sometimes called by this name. It is an equivalent of the term BRASH, used in some parts of England. Thus *cornbrash* is a brash or rubble of rotten limestone making a good corn land. Almost all quarries of limestone abound with this kind of substance.

The term is also applied to any stone broken from the quarry in rough irregular masses, and not subjected to any further dressing; stone reduced to a rectangular form being called ASHLAR.

Rubefacients (Lat. rubefacio, *I make red*). Substances which, when applied to or rubbed upon the skin, induce a redness or blush upon the part, not followed by blister.

Rubellane. An altered Biotite found in small, reddish-brown, hexagonal tables in Saxony, and at Schima in Bohemia.

Rubellite. Red Tourmaline containing a considerable proportion of manganese, to which it owes its colour. It generally occurs in closely aggregated crystals, varying in colour from a slight tinge of red to a fine pink. It is found in Ireland at Ox Mountain near Sligo, but the finest specimens are brought from Siberia, Moravia, and Paris in the State of Maine in North America. There is a magnificent group of crystallised Rubellite in the British Museum, from the cabinet of the late Mr. Greville, which was presented to Colonel Symes by the king of Ava, and which has been valued at 1,000*l*.

Rubenglimmer. The German name for a variety of Göthite of a hyacinth-red colour.

Rubeola (Lat. rubeo, *to grow red*). [MEASLES.]

Rubezahl. The name of a famous spirit of the Riesengebirge in Germany, who is celebrated in innumerable sagas, ballads, and tales, and represented under the various forms of miner, hunter, monk, dwarf, giant, &c. He answers to the English PUCK, and is said to aid the poor and oppressed, showing benighted wanderers their road, but waging incessant war with the proud and wicked. The origin of the name is obscure. (*Tales of Musæus.*)

Rubia (Lat. ruber, *red*). A genus of the *Galiaceæ*, an order closely allied to *Cinchonaceæ* (*Rubiaceæ*), and by many considered as a subdivision of that order. This genus furnishes the dye called Madder, which is the dried root of *Rubia tinctorum*. In the living roots the colouring matter is yellow, but it becomes red on drying. The best madder is imported from the

Levant, but some comes from Holland and France; the dye is much used in the latter country under the name of *Garance*. Some of the Indian species also yield a red dye. Madder has been stated to possess medicinal virtues; these, however, are so slight as to be now disregarded. The bones of young animals fed on madder become tinged with a red colour, and physiologists avail themselves of this fact in their researches on the mode of growth of bones. The stem and leaves of *R. tinctorum* are used in France for polishing metal-work, for which purpose their stiff hairs adapt them. The leaves and herbage also are used as fodder for animals.

Rubiaceæ. [CINCHONACEÆ.]

Rubian. An intensely bitter amorphous yellow substance, deposited on evaporating the alcoholic solution of the dried aqueous extract of madder. [MADDER.]

Rubicel or **Rubicelle.** A term applied to the Brazilian Ruby, and also to the yellowish or orange-red varieties of Spinel.

Rubinic Acid. *Rufocatechuic acid.* An acid formed by exposing a solution of catechuic acid in carbonate of potassa to the action of air.

Rubric (Lat. rubrica, as being originally written with red earth). In the language of the old copies of manuscripts, and of modern printers, any writing or printing in red ink. The date and place on a title-page being frequently in red ink, the word *rubric* has come to signify the false name of a place on a title-page. Many books printed at Paris bear the *rubric* of Genoa, London, &c. But the most common use of the word is in ecclesiastical matters. In MS. missals, the directions prefixed to the several prayers and offices were written or printed in red ink; and hence the *rubric* familiarly signifies the order of the liturgy, in Roman Catholic countries as well as in England.

Rubsen Cake. A kind of oil-cake made on the Continent, from the seeds of *Brassica præcox*.

Rubus (Lat. *a bramble-bush*). A familiar genus of *Rosaceæ*, to which are referred several of our common fruits, as the Raspberry, Blackberry, Dewberry, &c. The species are mostly shrubs, trailing or erect, having prickly stems, pinnate, quinate, ternate, or simply lobed leaves, and edible fruit. They are very well represented by the Bramble of our hedgerows, and the Raspberry of our gardens.

Ruby (Fr. rubis, Ital. rubino, from Lat. ruber, *red*). A term which, in strictness of speech, should be restricted to the *Oriental Ruby*, or to the red varieties of SAPPHIRE. Among lapidaries, however, the name Ruby is applied to several stones, of very different chemical composition, which they distinguish by their colours. Thus the scarlet coloured is called *Spinelle Ruby*; the pale or rose-red, *Balais* or *Balass Ruby*; the yellowish-red, *Rubicelle*; and those of a decided orange-red, *Vermeil* or *Vermeille*. The finest stones are found in the sand of rivers in Ceylon, in the Capelan mountains of Pegu, and in Ava. The Ruby, as a precious stone, ranks next to the diamond in value; in fact, a very fine ruby, of a carat or upwards, is more valuable than a diamond of the same weight. [STARSTONE.]

RUBY. In Printing, a kind of type two and a half sizes smaller than that used in this work. [TYPE.]

Ruby Silver. [PYRARGYRITE.]

Ruby Wood. One of the names under which Red Saunders wood, the timber of *Pterocarpus santalinus*, is known.

Rudder (Ger. ruder). A heavy flat piece or frame of wood, hung upon the stern post by means of pintles and gudgeons, for the purpose of steering the ship. The rudder is turned round the stern post as an axis, by the tiller, which enters the rudder head. In vessels drawing much water the rudder is deep and narrow; in flat-bottomed vessels, it is shallow and broad. When carried to a considerable breadth, as in the Chinese vessels, it is pierced with holes, which preserves an increased leverage with a diminished direct resistance from the water.

The action of the rudder may be thus explained. While it remains in line with the keel, the force of the water gliding past the deadwood or narrow portion of the stern is equal on both sides of the rudder, and equilibrium is maintained; but if the rudder be forced to one side, the pressure is taken off on the opposite side, while from acting at a less angle the water exercises an increased pressure on the side to which the rudder is turned. The effect is to force the stern round on the centre of gravity as a pivot, the ship's head, of course, turning to the same side as that on which the rudder is. When the head has sufficiently deviated from its former line, the rudder is permitted to resume its straight position. In sailing on a wind, the rudder is kept permanently on one side to counteract the tendency to make leeway.

Rudder Chains and Pendants. Short lengths of chain ending in ropes, for preventing the loss of a rudder in the event of its being unshipped in a heavy sea. The chains are shackled to the rudder by a bolt, in the back of it, just above the water-line, and the rope pendants are made fast to bolts in the stern quarters.

Ruddle. [REDDLE.]

Rudenture (Fr. from Lat. rudens, *a rope*). In Architecture, the rope, or staff, with which the lower parts of the flutings of columns are often filled. [CABLINGS.]

Rudiarius (Lat.). The term applied to a discharged gladiator. The word is derived from the staff (*rudis*) which was given him in token of his dismission. (Horace, *Ep.* i. 1, 2.)

Rudistæ. [HIPPURITES.]

Rudolphine Tables. A set of astronomical tables computed by Kepler, and founded on the observations of Tycho Brahe. They were called the *Rudolphine Tables* in honour of Rudolph II., emperor of Bohemia, who, upon the death of Tycho in 1601, conferred upon

Kepler the title of imperial mathematician, and undertook to defray the expenses of their preparation. Owing to various causes the work was not completed until 1627, when the tables were published at Ulm. They are the first that were ever calculated on the hypothesis that the planets move in elliptic orbits, and they contributed greatly to the progress of modern astronomy. For a detailed account of this very remarkable production, see Delambre, *Astronomie Moderne*, tom. i. p. 557.

Rue (Lat. ruta, Gr. ῥυτή). The common name of *Ruta graveolens*, a native of the South of Europe, commonly cultivated in this country. It is a shrubby plant, with pinnately divided bluish-green leaves, and yellowish flowers, the whole plant possessing a powerfully fetid odour and acrid taste, dependent on the presence of a volatile oil. Rue is used medicinally as a stimulant and narcotic in flatulent colic, hysteria, &c. Locally applied, it acts as a powerful irritant. One species, indeed, *R. montana*, is said to be so powerful that it is dangerous to handle the plant, even when the hands are protected by gloves. Rue was employed medicinally by the ancients: for ages it was considered potent to ward off contagion, and it is still employed to keep off noxious insects. Rue enters into the composition of the French perfume, entitled *Vinegar of the four thieves*. [Thieves' Vinegar.] The Italians are stated to eat the leaves in salads. Shakspeare speaks of Rue as herb of grace.

Ruff. The name of the male of the *Machetes pugnax*, which is distinguished at the breeding season by a ruff or tuft of wide-spreading feathers, projecting behind the eyes and from the upper part of the neck. The female is called the *reeve*. [Machetes; Tringa.]

Rufin (Lat. rufus, *red*). A red substance formed by the action of heat on phloridzin.

Ruin Marble. [Cotham Marble.]

Rule (A.-Sax. regol, Ital. regola, Lat. regula). In Arithmetic, denotes a certain prescribed series of numerical operations, adapted to discover, from the given conditions to which an unknown number is subjected, what that number is. They are generally distinguished by particular names, according to the purposes for which they are given, or the particular nature of the business for which they are required; as the rules of interest, the rules of fellowship, &c.

Rule. In Law, an order of one of the three superior courts of common law. Rules are either general or particular; the former being such orders relating to matters of practice as are laid down and promulgated by the court for the general guidance of the suitors: the latter are such orders as are confined to the particular case in reference to which they have been granted.

The term is often used generally to denote a legal doctrine. [Courts, Superior; Pleading.]

Rule. In a monastic sense, a system of laws or regulations by which monasteries and other religious houses are governed, and which the monks, nuns, and novices vow, on their entrance, to observe. [Monachism; Orders, Monastic.]

Rule, Carpenter's. A folding ruler, generally used by carpenters and other artificers, having a variety of scales adapted to facilitate by inspection the calculations of most frequent occurrence. Sometimes it has a sliding piece in one of its legs, by which its use is greatly extended. [Sliding Rule.]

Rule, Gauging. A rule adapted to discover the contents of casks and other vessels. It is used by the officers of excise in surveying, in the process of manufacture, articles that are liable to duties. [Gauging.]

Rule of Signs. Besides the rule known in the theory of equations as Descartes' Rule of Signs, there is another of frequent use in the theories of permutants, commutants, determinants, &c. which may be thus ennunciated: *Any primitive arrangement of symbols being fixed upon, the sign to be prefixed to any other arrangement of the same symbols is positive or negative according as the latter arrangement is obtainable from the first by an even or odd number of successive interchanges of two symbols.*

This rule involves no ambiguity; for although there are many different ways of deriving a given arrangement from the primitive one by successive interchanges of two symbols, it can readily be shown that the number of such interchanges is constantly even or else constantly odd. Thus 1, 2, 3, 4, 5, being the primitive arrangement, 1, 4, 5, 2, 3, will be a positive and 2, 5, 1, 4, 3, a negative one in whatever manner the latter may be derived from the first by successive interchanges of two symbols. The rule of signs as ennunciated by Cramer (*Analyse des Lignes Courbes*, 1750) is often more convenient in practice. *An arrangement is positive or negative according as it contains an even or odd number of displacements*; it being understood that a displacement consists in the inversion of the order of sequence of any two symbols, in the primitive arrangement. Thus, since in the arrangement 1, 4, 5, 2, 3, the numbers 4 and 5 each *precede* two lower numbers; instead of being preceded by them as in the primitive arrangement, there are *four* displacements, and the arrangement is positive; again, in 2, 5, 1, 4, 3, the circumstance of a greater number preceding a less occurs *five* times, so that the arrangement is negative.

The equivalence of the above two rules can be easily proved. [Permutations.] It is established in Balzer's *Theorie und Anwendung der Determinanten*, Leipzig 1857, and was first demonstrated, by Laplace (*Histoire de l'Acad. de Paris* 1764).

Rule of Three. In Arithmetic, the rule by which when three numbers are given a fourth is to be found, so that the four shall be in direct or inverse proportion, as the case may require. [Golden Rule.]

Rules. In Building operations, this term is applied to the screeds, or portions of plastering executed on the face of a wall for the purpose

of floating the works in order to retain their perpendicularity, or their evenness of surface.

RULES. In the Fine Arts, those laws and maxims, founded on the general and fundamental truths of nature, by which artists are guided in their compositions.

Rules, Brass. In Printing, pieces of brass of different thicknesses made letter high, to print with type. They are made in lengths of fourteen inches, but of late years lengths half as long again have been made. One of the edges is bevelled so as to print a fine line; and when a thicker line is required, the bottom edge is placed uppermost, which is the full thickness of the brass; by this means lines of different thicknesses are obtained, and also double lines, a thick one and a fine one, when required. They are used for column lines in table work; to separate matter that requires to be distinct; and to be placed round pages. In cases where diagrams are required, and there is no engraver within reach, they may be formed by a clever workman with brass rule.

Ruled Quadric. In Modern Geometry, a ruled surface of the second order. Besides the cone and the three cylinders, there are two ruled quadrics, the hyperboloid of one sheet and the hyperbolic paraboloid, both of which are *skew* quadrics. [QUADRIC; RULED SURFACE.]

Ruled Surface. In Geometry, a surface generated by the motion of a straight line. At every point of such surface, therefore, a straight-edge or *ruler* may be applied so as to lie wholly on the surface. The straight line is called the *generator*; if every pair of successive generators intersect one another, or are in the same plane, the ruled surface could obviously, without crumpling or tearing, be unfolded into a plane, on which account it is called a *developable surface*: in other cases where two consecutive generators do not intersect, it is said to be a *skew surface*.

The motion of the generator may be defined in many different ways, and the treatment of the problem of finding the ruled surface will vary accordingly. Frequently the motion of the generator is regulated or directed by three curves or *directrices*, each of which the generator must always cut. That this is possible, is evident on considering that the cones whose common vertex is a point on one direction, and whose generators rest on the other two respectively, will necessarily intersect each other in a finite number of lines, cutting all three directrices. In fact, if n_1, n_2, n_3 denote the orders of the three directrices, there will be $n_2 n_3$ generators through every point of the first, $n_3 n_1$ through every point of the second, and $n_1 n_2$ through every point of the third; so that the three directrices will be multiple curves on the ruled surface; the orders of multiplicity being, respectively, $n_2 n_3$, $n_3 n_1$, $n_1 n_2$. To determine the order x of the ruled surface itself, or the number of its generators which meet any arbitrary line, we have, in the first place, to remember that a curve of the n^{th} order in general cuts a surface of the m^{th} in mn points. [CURVE.] Now, if x_1 be the order of the ruled surface whose directrices are the curves (n_2), (n_3), and any right line A_1, the curve (n_1) will meet $n_1 x_1$ of its generators. But these are clearly generators of the required surface meeting an arbitrary line A_1; hence $x = n_1 x_1$. In a similar manner, if x_2 be the order of the ruled surface whose directrices are (n_3), A_1, and another arbitrary line A_2, then $x_1 = m_2 x_2$; but, lastly, the ruled surface whose directrices are three right lines A_1, A_2, A_3, is of the second order, hence $x_2 = 2m_3$, and thus $x = 2n_1 n_2 n_3$.

To find the equation of the surface, we might proceed thus:

$$x = a z + a, \; y = \beta z + b,$$

being the equations of any generator, and $U = 0$, $V = 0$ those of one of the directrices, the elimination of $x\ y\ z$ from the four equations will give a relation between a, a, β, b; two similar relations will be obtained from the other directrices, so that, counting the two equations of the generator, we shall have, on the whole, five equations, from which if a, a, β, b be eliminated, the equation of the ruled surface will be obtained. For other properties of ruled surfaces, see SKEW SURFACE and DEVELOPABLE. Some of the most instructive works on the subject are those of Monge, *Application de l'Analyse à la Géométrie*; Dupin, *Developpements de Géométrie*; Chasles, *Quetelet's Correspondance*, t. xi.; Cayley, *Cambridge and Dublin Math. Jour.* vol. vii. &c.; and Salmon, *An. Geom. of Three Dimensions*. An important curve on every ruled surface is its *line of striction*, or the locus of the point on each generator which is nearest to the consecutive generator. [SKEW SURFACE.] It may be added, too, that the polar reciprocal of a ruled surface is another ruled surface of the same order.

Rum (a word of unknown origin). A spirituous liquor distilled from the fermented juice of the sugar cane, or from molasses. Its flavour is due to the presence of a peculiar volatile oil: its average proportion of alcohol fluctuates between 50 and 56 per cent. The rum consumed in the United Kingdom is manufactured chiefly in the islands belonging to Great Britain. It was formerly supposed that the consumption of rum would be aided by the imposition of differential duties on the produce of other countries; and hence the old duty on West India rum was 9*s*., on that imported from other regions 15*s*. But the duties on all spirits, whatever be their origin, are now equalised, and the effect has been that the consumption has been determined by dearness and cheapness. It is the practice of government to put the duty on spirits at that point which is just below the temptation to smuggling and illicit distillation. There is, it is reported, some difficulty in discovering this limit. In all probability it varies with the material

prosperity of the consumers. In the year ending March 1865, the customs duty on rum amounted to 1,908,057*l.*; on brandy, to 1,246,158*l.*; while the excise on spirits was upwards of ten millions. The cheapest article is the most productive. West India produce has still some slight protection in the fact that rum is still used almost exclusively in the navy. This practice—originally part of our colonial policy—is, it is said, judicious, for, of all spirits, rum, when kept long enough and properly mixed, is reported to be the most wholesome.

Rumen (Lat.). The name of the paunch or first cavity of the complex stomach of the Ruminant quadrupeds.

Rumex (Lat. sorrel). A large genus of weedy herbaceous plants, represented by the common Dock, one of the greatest pests to the agriculturist. The most useful species are the Sorrels, *R. acetosa* and *R. scutatus*. The former of these, the Common Sorrel, was cultivated in gardens for its leaves, which were used as spinach or in salads, in the time of Henry VIII.; but since the introduction of the French Sorrel, it has gradually lost its position as a salad and potherb. *R. scutatus*, or French Sorrel, is considered preferable to the common, on account of its leaves being larger and more succulent, with rather less acidity. The Sorrels are all of great importance in French cookery, and are both agreeable to eat and very wholesome, although but little valued in this country, except at some of the most fashionable tables. On the Continent sorrel is extensively cultivated, and in the vegetable markets of Paris it is nearly as abundant during the season as peas are in those of London. It abounds in oxalic acid, and is regarded as a powerful antiscorbutic.

Ruminants (Lat. rumino, *I chew the cud*). The name given by Cuvier to the *Pecora* of Linnæus, an order of Ungulate Mammals, including those which have a complicated stomach of four cavities so disposed as to allow of rumination, and a cloven hoof.

Ruminated (Lat. rumino, *I chew*). In Botany, a term applied to those seeds in which the albumen is penetrated by irregular channels filled with softer cellular matter, as in the Nutmeg.

Rumination (Lat. ruminatio). The act by which food once chewed and swallowed is a second time subjected to mastication. Digestion is always preceded by this action in the order of Mammals, hence called *Ruminants*; but very rarely, and as an exceptional case, in any other animal. The stomach of the Ruminants is specially organised for rumination, consisting of four distinct cavities, all of which communicate with a muscular canal at the termination of the œsophagus. Hard, solid, or coarsely masticated food, passes from the beginning of the muscular canal into the first cavity of the stomach, called the *rumen* or paunch. Water is received into the second cavity, called the *reticulum*, and almost exclusively occupies the honeycomb cells of that cavity; it is gradually mixed with the coarsely divided food which is undergoing mastication in the rumen. When this is sufficiently advanced, a portion of the mass is received into the muscular canal at the termination of the œsophagus; it is there moulded into a ball, and propelled by a rapid and inverted action of the muscles of the gullet into the mouth, where it is more perfectly masticated, mixed with fluid, and again swallowed. It now passes directly into the third stomach, called the *psalterium*, from the broad leaf-like plates of membrane with which it is occupied. Here the superfluous fluid, which otherwise might have too much diluted the gastric juice, is absorbed, and the subdivided cud passes gradually into the fourth or true digesting stomach, called the *abomasus*. In the camel tribe, water-cells are developed at the sides of the rumen, in addition to those of the reticulum, and the psalterium is not separated by any contraction from the abomasus.

Rump Parliament. In English History, after the dissolution of Richard Cromwell's parliament, and his own demission of the protectorate, a council of officers, at whose head were Desborough, Lambert, and others, having seized the supreme authority, found it advisable to call together the remnant of the Long Parliament, which had been forcibly dissolved by Oliver. It was assembled in May 1659; and consisted of little more than seventy members, those who had been excluded not being allowed to resume their seats. This body soon became odious to the Presbyterian and Royalist parts of the nation, and by its own assumption of power displeased the officers who had called it again into being. It acted, however, with some vigour and determination, and defeated a variety of royalist conspiracies; but when it ventured so far as to cashier Lambert and others of the leading officers, the troops again surrounded Westminster Hall, and expelled it on the 13th October in the same year. As, however, Fleetwood, who had the command of the army, was unable to keep together the distracted government, the officers once more invited the parliament to sit again, and on the 26th of December it once more assumed absolute authority; but General Monk took part against it. On his invitation, a good many of the excluded members went to the house (Feb. 21), and thus placed the Independents, who had hitherto ruled it, in a minority; and having passed some measures reversing its former acts, the parliament dissolved itself. It received its nickname from being, as it were, the remnant and fag-end of the old Long Parliament, and was treated by the nation with general contumely and derision. But it cannot be denied that, utterly unable as it was to command the divided nation, it showed in its conduct a boldness and vigour which with a little more popularity would probably have insured success. Vane and Hazlerig were its leading members.

Runcinate (Lat. runcina, *a large saw*). In Botany, having lobes hooked back, or curved in a direction from the apex to the base; as the lobes of the leaf of the dandelion.

Runes (Ger. runen). Properly the signs or letters of the ancient alphabet peculiar to the northern nations (Germans and Scandinavians). There are three theories on this subject, one maintained by Schlözer, who holds the sixteen Runic letters to be a corruption of the Roman alphabet, post-Christian in date; the second, that of Schlegel, who deduces this alphabet from the Phœnicians. (*Lectures on Ancient and Modern Literature.*) The third theory supposes the Runic to be the original character of the Indo-Teutonic tribes, brought from the East and preserved among the different races of that stock. The earliest writer who mentions the Runic characters is Venantius Fortunatus, in the sixth century. The Runic inscriptions found in Germany (especially Northern Saxony) are thought by some to exhibit tokens of an origin somewhat different from Scandinavian. (Grimm, *On the German Runes*, 1821.) The antiquity of both has been much disputed. Of those found in Gothland, it is said that the oldest are not earlier than A.D. 1200, the latest 1449. 1,300 stones with Runic inscriptions have, it is said, been discovered in Sweden; many in Denmark; none in Lapland or Finland. Runic staves are massive sticks, generally of willow, inscribed with Runic characters, probably of magical import. (Gibbon, *Roman Empire*, ch. ix. vol. i. 231, Milman's edition.)

Runner. In Botany, any slender prostrate stem, which throws out roots at the extremity, as in the Strawberry.

Runner Tackle. A luff tackle applied to the running end of a rope passed through a movable pulley.

Rupee. A coin circulating in the Indian peninsula. There are two kinds of rupee, the sicca rupee, estimated at 1*s.* 11·77*d.* sterling, and that known familiarly as *the Company's* rupee, worth fifteen-sixteenths of the former, and therefore valued at 1*s.* 10·29*d.* sterling, reckoning silver at 5*s.* the oz. A *lac* is 100,000, a *crore* 10 millions of rupees. [Money.]

Rupia (Gr. ῥύπος, *filth*). An eruption of flattish vesicles, succeeded by an ill-conditioned discharge, which concretes into scabs easily rubbed off and regenerated; they sometimes occur as a consequence of poor diet and weak habit of body; but there is a rupia which constitutes one of the most painful sequelæ of syphilis. Light nutritious food, tonics, and alteratives are the remedies.

Rupture. [Hernia.]

Rural Dean. An officer of the church, originally a kind of deputy of the bishop, for the purpose of inspecting the conduct of the parochial clergy within the limits of his deanry, enquiring into and reporting dilapidations, &c. This office had become nearly obsolete, but it has been resuscitated in modern times, and is now in general use. Rural deans receive no payment, and exercise no jurisdiction; their office is one of inspection only.

Rural Economy. The general management of territorial property, either by the proprietor or his agent. On a small scale, the agent is termed a *bailiff* or *farm servant*; and on a large scale, a *land steward* or *factor*. The duties of the latter are to collect the rents, to maintain the general equipment of the estate, and to see that the different clauses in the leases by which the tenants hold their lands are fulfilled; of the former, to cultivate the land in such a manner as to produce the greatest profit, or to fulfil the intentions of the proprietor as to the kind of produce which he considers it desirable to obtain. [Agriculture.]

Rush, Polishing. The Polishing Rush or Dutch Rush are commercial names of *Equisetum hyemale*, which in consequence of the large quantity of silex contained in its tissues is imported, principally from Holland, as a material for polishing wood, ivory, and brass. The greater number of the particles, according to Brewster, form simple straight lines, but the rest are grouped into oval forms connected together like the pearls of a necklace by a chain of particles, these rows of oval combinations being arranged in pairs. The straw and chaff of wheat, &c., which when burnt is also good for polishing, presents analogous phenomena, but the particles are arranged in a different manner.

Russian Mats. A kind of matting manufactured in Russia from the inner bark of the Linden, *Tilia europæa*. Russian mats are used in packing, and also as a protecting material in gardens; while the *bast* of which they are formed is used for tying up plants.

Rust (Dutch roest, Ger. rost, perhaps akin to *crust*). In its ordinary acceptation, the reddish peroxide which is found on the surface of iron when exposed to moisture.

Rust. In Horticulture. [Mildew.]

Rust. The common name of *Trichobasis Rubigo vera*, a parasitic fungus, which, with one or two closely allied species confounded with it by the farmer, preys upon the leaves, glumes, stalks, &c., of Cereals. Rust does not appear to be injurious to corn, so long as it is confined to the flaggy leaves, as it seldom grows except when they are over-luxuriant, but it is a formidable adversary when it attacks the chaff or seed; and the more so because it is impossible to suggest any remedy. Every protospore is shed long before the grain is reaped; therefore steeping is useless, and the application of any dressing to the soil is equally ineffectual.

Rustem. In Persian Mythology, a hero who slays Isfendiyar, as Sifrit is slain in Teutonic legends, by casting a thorn into the one spot where, like Achilles and other solar heroes, he is vulnerable. Rustem in his turn can be killed only by his brother, as Baldr can be slain only by the mistletoe, and as Hector can be slain only by Achilles, and the latter only by Paris, who again can be fatally wounded only by the poisoned arrows of Heracles. [Mythology, Comparative.]

Rustic (Lat. rusticus, from rus, *the country*). In Architecture, a name applied to masonry employed in basements with large joints to mark the different courses of stones. It is applied to work left with an irregular surface, or jagged out in an irregular manner.

Rutabaga. The Swedish Turnip, *Brassica campestris rutabaga.*

Rutaceæ (Ruta, one of the genera). A natural order of hypogynous Exogens, of the Rutal alliance, composed principally of trees and shrubs inhabiting the warmer parts of the world, seldom of herbaceous plants. They are known by their hermaphrodite flowers, few-seeded, prickly apocarpous fruit, and sessile pendulous ovules. The species are sometimes very ornamental, especially those belonging to the genera *Correa, Boronia,* and *Diosma.* Some, as the common Rue, the Buku plant, &c., are remarkable for having a powerful, peculiar, unpleasant odour, and antispasmodic quality; and a few have a febrifugal bark. The *Dictamnus albus,* or Fraxinella, is extremely fragrant, and gives off an inflammable vapour.

Ruthenium. A metal closely resembling iridium, with which it is associated in the residue from crude platinum insoluble in aqua regia. [PLATINUM.]

Rutherfordite. A titanate of lime found in iron-black crystals and grains, at the Gold-washings of Rutherford county, North Carolina.

Rutile (Lat. rutilus, *shining red*). Native titanic acid; composed, when pure, of 60·98 per cent. of Titanium and 39·02 oxygen. It is found crystallised and massive in Argyleshire, Perthshire, Fifeshire, and the Shetlands; also in France, the Alps, Brazil, &c.

Rutilite (Lat. rutilus, *red*). Native titanate and silicate of lime. [SPHENE.]

Rutinic Acid. An acid contained in the leaves of rue.

Rutton-root. The name of an Indian dye root, that of *Maharanga Emodi.*

Ryacolite (Gr. ῥύαξ, *a* [*lava*] *stream,* and λίθος, *stone*). A silicate of alumina, soda, potash and lime, occurring in thick tabular, or short prismatic crystals, like Glassy Felspar, of which it is, perhaps, only a variety. It is white or of a grey colour, with a vitreous lustre, and is transparent or translucent. It is chiefly found at Vesuvius in ejected blocks with Nepheline, Augite, and Mica; and at Lake Laach.

Rye (Ger. roggen, Dutch rog, rogge). One of the Cereal grasses, which, according to some, is a native of Crete, but according to others is found wild in the Crimea. It has been cultivated from time immemorial, and is considered as coming nearer in its properties to wheat than any other grain. It is more common than wheat in many parts of the Continent, being a more certain crop, and requiring less culture and manure. It is the bread-corn of Germany and Russia. In Britain it is now very little grown, being no longer a bread-corn, and therefore of less value to the farmer than barley, oats, or peas. Its chief use in English agriculture arises from its early spring growth. The St. John's Day rye, sown soon after midsummer, stands the winter, and, cut in April, furnishes the earliest green food available for the stable, byre, or sheepfold in spring.

Ryot (Arab. *a peasant* or *serf*). The cultivators of the soil in Hindustan, who pay the land tax are designated by this name; the proportion, one-sixth in peace, one-fourth in war, at which the rate should be levied from the produce having been determined in the ancient sacred works of the Hindus. It was seldom, however, that the native rulers were content with the quantity fixed by these authorities, but generally taxed their subjects to the fullest possible extent.

When the English obtained possession of Hindustan, they adopted the system of farming the revenues. Such an expedient was no improvement on the administration of the native princes. The farmers were an army of tyrants. Holding their office for a short time only, they were eager to procure every possible advantage to themselves; and being checked by no efficient control, they cruelly abused the powers necessarily accorded to their office. The farmers actually depopulated the country.

The inconveniences which followed on this system induced Lord Cornwallis to attempt a change. He, no doubt, meant honestly and fairly by the natives; but being wholly ignorant of the peculiar land tenures of India, and the rights involved in them, he attempted to set up a modified feudal system. The farmers were turned into landlords under the title of *zemindars,* were rendered liable to a fixed and permanent tax, and received rents from the ryots. Remedies in English courts of law were supplied to the ryots in case they were oppressed by their new masters.

These zemindars were a local aristocracy in name only. They were often despised by the rajpoots as persons of inferior caste; in all cases they had been elevated to the rank which they occupied by the force of purely fortuitous causes. The natives availed themselves of the assistance of the English law courts. In one district it is said that no less than thirty thousand suits were lodged against the zemindars. But these officials, though liable to summary procedure if they defaulted for a single month in the payment of their taxes, could proceed against the ryots only by very slow processes. Added to this, they were often, as many other upstarts are, profligate, licentious, and extravagant. In a very short time the zemindary system disappeared, and in its place a settlement was made for thirty years at a variable rent. In effect it is found that this arrangement has not been satisfactory, and considerable disaffection has from time to time been expressed by the natives of the Bengal presidency and their advocates.

In Madras, into which the Mohammedan conquerors had not penetrated, the ancient village system prevailed, with its headman, who governed the land, distributed its products, and was responsible for the payment of taxes

to government. Here the occupation of the English led to investigations into the system by which the land tax was levied, and a new plan, the exact reverse of the zemindary system, was instituted. Colonel Read and Sir T. Munro set up what has been called the ryotwary system; the chief feature of which was, that the government was henceforth to transact its business with the individual ryot, no other person intervening. This scheme annihilated the ancient village system, which had prevailed for so many ages in India, and induced as a consequence enormous social difficulties. Besides, as under this new method it was necessary to map out and measure an infinity of allotments, the physical difficulties were almost insuperable; not to mention the prodigious expense of such an admeasurement, and the inevitable discontent that would arise. To complete the folly, it was resolved to make the rent permanent, as if a peasant could pay a fixed rent with equal ease in all seasons and under all circumstances.

After having destroyed the village system, and having found it necessary to abandon the zemindary and ryotwary, the government attempted to revive the village system in a modified form, under the name of Mouzawar. The plan failed, for the new headmen of the villages, not having been appointed in pursuance of the traditions of the ancient Indian institutions, were avaricious and oppressive, and odious to the ryots.

It became necessary then to establish the ryotwary system on a new basis; and having gained experience from past errors, the Indian land tax was put on as fair a basis as was possible under the circumstances.

The principal members of the Hindu village, according to Mr. Richard Jones, were the headman, the registrar, the police magistrate, the land measurer, the boundary man, the Brahman or priest, the schoolmaster, the astrologer, the smith or carpenter, the potter, the washer-man, the barber, the cow-keeper, the doctor, the dancing girl, the musician, and the poet.

Rytina (Gr. ῥυτίς, *a wrinkle*). The name of a genus of herbivorous Sirenia, of which a species formerly inhabiting the coasts of Kamschatka (*Rytina Stelleri*), with a wrinkled and furrowed integument, is the type. Descriptions of this animal were given by Steller in the *Transactions of the Academy of St. Petersburg*, a few years after its discovery in the eighteenth century. The whalers who traded to Behring's Straits and the northern shores of Siberia killed large numbers of this animal for the sake of the blubber and oil; the result being the complete extinction of the species, of which no individuals exist at the present time in a living state.

S

S. A sibilant articulation, found in all the languages of which we have any knowledge. S may be regarded as a species of semivowel, from its forming a kind of imperfect sound without the aid of any of the vowels; and from its peculiar quality of being able to be sounded before all the consonants, it has been termed by grammarians *suæ potestatis litera*, It is susceptible of many interchanges, both in the ancient and modern languages. As an abbreviation, S is used for *socius*, *societas*, *south*, *solo*, &c. [DIGAMMA.]

Sabadilline. One of the poisonous alkaloids of white hellebore.

Sabaism (from the Heb. zaba, *lord*; whence sabaoth, &c., or *army*, *the host of heaven*). The religion which has for its objects of worship the sun, moon, and other heavenly bodies. This belief prevailed in very remote ages in the Asiatic countries between the Euphrates and the Mediterranean; and Chaldæa, the native land of astronomy, was its most celebrated seat. Sabaism was one of the various forms of idolatry borrowed by the Jews from their heathen neighbours. It was also widely prevalent in Arabia; and according to some recent and singular revelations respecting that country, still subsists in parts, under the cover of an ill-assumed Mohammedanism. (Sale's *Preliminary Discourse to the Koran*; *Mém. de l'Acad. des Inscr.* vol. xxv. p. 100; Palgrave's *Central Arabia*.) The word *Sabaoth* occurs in the New Testament as a designation of the Almighty (the Lord of Sabaoth).

Sabal. A genus of Palms, including one of the most northern representatives of that order, *S. Palmetto*, reaching in Carolina as far north as lat. 34° 36′. They have large fan-shaped leaves, and in some species stems of twenty to thirty feet high. The soft interior of the short stem of *S. Adansoni* is eaten in the southern states of America, and its leaves, as well as those of *S. Palmetto*, are used for plaiting into hats, resembling what in this country are called *chip-hats*. In Mexico the leaves of *S. mexicana* are applied to a similar use.

Sabazius (Gr. Σαβάζιος). A Phrygian divinity, identified by the Greeks with DIONYSUS. Zeus, however, is also sometimes called Zeus Sabazius. Serpents, which were sacred to him, were borne in processions made in his honour.

Sabbatarians. In Ecclesiastical History, various sects have been so called; particularly a subdivision of the Anabaptists in the six-

teenth century, who observed the Jewish sabbath. The *Sabbatians* of the fourth century were followers of Sabbatius, a Novatian bishop. (Socrates, *Hist. Eccl.* v. 21.)

Sabbath. A Hebrew word signifying *rest*, applied by the Jews to the seventh day of their week (our Saturday), on which they were commanded to abstain from all manner of work. The universal practice of the Christian church from a very early period has set apart the first day of the week (Sunday) in especial memory of the Resurrection. The obligation upon which the observance of Sunday rests has been placed upon different grounds. (Hessey's *Bampton Lectures* for 1860; *Edinburgh Review*, Oct. 1861; Robert Cox, *Literature of the Sabbath Question.*)

Sabbatical Year. Every seventh year among the Jews was so called, in accordance with the precepts given in Exod. xxiii. 10, Lev. xxv. 3, 20.

Sabellians. The followers of Sabellius, in the third century, whose system was an attempt to explain the doctrine of the Trinity by representing the Father as the sole Person, and the Son and Spirit as attributes, or emanations from Him. Thus they compared the Divinity to the sun; of which the Father would be analogous to the substance, the Son to the light, and the Holy Ghost to the heat. This scheme has been known in later times as that of the Modal Trinity; and some divines of the church of England appear to have adopted it, when attempting to explain accurately the doctrine to which it refers, while their opponents, making too formal a distinction of the Three Persons, have been subjected to the charge of Tritheism.

The followers of Praxeas, who maintained the Sabellian thesis, asserted that the Father had united to Himself the human nature of Christ, and were hence called Monarchians, while they were also styled *Patripassians*, as holding that the Father suffered in the death of Christ.

Sabiaceæ (Sabia, one of the genera). A small order of hypogynous Exogens, nearly allied to *Sapindaceæ* and *Anacardiaceæ* in the structure of the ovary, fruit, and seeds, but differing essentially in the stamens being equal in number and opposite to the petals, two of the stamens being usually much larger than the others and perfect, the two or three others much smaller and often without anthers. The species are all tropical trees, shrubs, or woody climbers, with alternate simple or pinnate leaves without stipules, and small flowers usually paniculate. They occur both in the New and the Old World.

Sabians. A Christian sect, also called Christians of Saint John; thought by some to be the remnant of the Jewish Hemerobaptists found in Persia and Arabia, principally at Basra. (*Mém. de l'Acad. des Inscr.* vol. xii.; and Mosheim, vol. iv.)

Sabicu Wood. A hard shipbuilding timber, obtained from Cuba, and produced by *Lysiloma Sabicu*. It is sometimes called Savicu or Savico Wood.

Sable (Ger. zobel, Fr. zibeline). A small quadruped, allied to the marten-cat, celebrated for the fine quality and rich colour of its fur, of which the hairs turn with equal ease in every direction. A single skin of the darker colour, though not above four inches broad, has been valued as high as 15*l*. The sable (*Mustela zibellina*, Linn.) is principally a native of the northern regions of Asia: it is hunted and killed for the Russian market, either by a single ball, a blunt arrow, or traps, by exiles or soldiers sent for that purpose into the deserts of Siberia. The skin is in the highest perfection from November to February. A nearly allied animal, called the *fisher*, inhabits North America, and is similarly sought after and destroyed for its fur.

Sable. In Heraldry, *black*: derived, probably, from the fur of the animal sable. One of the colours, or tinctures, employed in blazonry. It is equivalent to diamond among precious stones, Saturn among planets. In engraving, it is represented by vertical and horizontal lines crossing each other.

Sabôt (Fr.). In Artillery, a wooden top or bottom fixed to a shell, in order to keep the shell from rolling while entering the bore, thus insuring that the fuse is not next the charge, in which case the shell would burst in the gun. It also saves the bore of a bronze gun from injury by the rebounding of the shot.

The name *sabôt* is also given to the heavy wooden shoe worn by the poorer classes in France.

Sabre (Fr.). A curved sword used by cavalry.

Saccharic Acid (Lat. saccharum, *sugar*). An uncrystallisable acid product, formed along with oxalic acid during the action of nitric acid on sugar.

Saccharimetry. The operation of estimating the amount of sugar in any substance that may contain it. The specific gravity is sufficient for this purpose in the case of pure syrups. In some other cases advantage is taken of the extent to which a given volume of a saccharine solution twists a ray of polarised light. The latter operations may also be applied in the case of mixtures of cane and grape sugar. Both twist the ray to the right, but the former alone has this power inverted on ebullition with hydrochloric acid; a fact which, when applied, obviously affords experimental data for the calculation of the quantities of each present. Another saccharimetric method consists in converting the cane sugar into grape sugar by boiling with dilute sulphuric acid for two or three hours, and then heating with solution of potash or soda, and comparing the depth of colour of the resulting dark brown liquid with similar liquors prepared from known weights of sugar. Grape sugar will also reduce an alkaline solution of tartrate of copper with precipitation of orange yellow sub-oxide of copper. This reaction is perfectly definite, and may be applied in the estimation of grape or cane sugar, or both.

Saccharite (from its saccharine appearance, like that of loaf-sugar). A hydrated variety of Andesine, occurring in finely granular masses of a white or greenish colour, forming veins in Serpentine at the chrysoprase mines near Frankenstein in Silesia.

Saccharoid (Lat. saccharum, and Gr. εἶδος, *form*). A texture resembling that of loaf sugar; as saccharoid carbonate of lime, &c.

Saccharometer (Lat. saccharum, and Gr. μέτρον, *a measure*). An instrument for determining the specific gravity of brewers' and distillers' worts.

This name is also given to an instrument for determining by polarised light the quantity of real sugar in saccharine solutions.

Saccharum (Sansc. sarkara). A genus of grasses, the most important species of which is *S. officinarum*, the Sugar-cane, which has been cultivated from time immemorial, and was known to many savage tribes of the Eastern hemisphere, who grew it for the sake of sucking the stem or sweetening their food with the raw juice. The native country of the Cane is doubtless the Eastern hemisphere, but the exact locality whence it spread is unknown. India lays claim to it, and our name Sugar is a corruption of a Sanscrit word. New Caledonia, in the South Pacific, has also a peculiar claim to be regarded its native country, for there the Sugar-cane grows with rapidity and attains an extraordinary size, and the barbarous natives of that large island possess an endless number of varieties. The manufacture of sugar is supposed to have been derived from China. The consumption of sugar is largest in Australia, where the European population uses about 100 lbs. per head; whilst in England 36 lbs. and in Russia only 2 lbs. per head are consumed. Sugar is made into molasses and rum, and is also used medicinally. [SUGAR.]

Sacer Morbus (Lat. *sacred disease*). One of the names applied by the older writers to epilepsy, though other disorders were also occasionally similarly designated.

Sack (Fr. vin sec, *dry wine*). A Spanish wine of the dry kind. The important part which it plays in Shakspeare is well known. Falstaff calls it *sherris sack*, which means sherry sack; so called, says Blount, in his *Glossographia*, from Xeres, a sea-town of Corduba, where that kind of sack is made. At a later period, sack seems to have been used as a general term for all kinds of sweet wines; and it has been conjectured that, instead of being a corruption of the French *sec*, as above noticed, it derives its name more probably from a common practice of the Spaniards, of putting their sweet wines into *sacks* made of goat skins, and thus transporting them from one place to another.

Sack-tree. [LEPURANDRA.]

Sackbut (Fr. saquebute, Span. sacabuche). A wind instrument of the trumpet species, but different from the common trumpet in form and size. It is of low or bass pitch, and is drawn out or shortened by the means of sliders, according to the acuteness or gravity of the tone to be produced. It is, in fact, the trombone of the Italians.

Sacrament (Lat. sacramentum, *an oath*). The military oath taken by every Roman soldier, by which he swore to obey his commander and not desert his standard.

SACRAMENT. In Theology, a word employed very early by writers in theology to signify certain distinctive ceremonies of the Christian faith, and especially the rite of Baptism, and the Eucharist or Lord's Supper. The former of these two sacraments is frequently called the second birth, the other is said to be the communion of the body and blood of Christ, while both are represented as having in themselves a peculiar efficacy, conferring grace upon the recipient, and imparting to him the benefits of the Christian covenant. The Roman church is accused of holding the opinion that this grace is conferred ex opere operato, by the mere act, the recipient remaining passive, and that they fail of operation only where he is under the influence of positive sin. According to Article XXV. of the Established Church of England, 'Sacraments ordained of Christ be not only *signs* or *tokens of Christian* men's profession; but rather they be certain sure witnesses and effectual signs of grace, and God's will towards us, by the which He doth work invisibly in us, and doth not only quicken, but also strengthen and confirm our faith in Him.'

The same article asserts that 'there are two Sacraments ordained of Christ our Lord in the Gospel, that is to say, Baptism and the Supper of the Lord,' and refuses the title of *Sacraments of the Gospel* to the five ordinances of Confirmation, Penance, Orders, Matrimony, and Extreme Unction, which, with those of Baptism and the Eucharist, make up the seven sacraments of the church of Rome.

Sacred War. The most remarkable war known by this name in classical history is that which commenced with the seizure of Delphi by the Phocians, B.C. 357, and was ended by the conquest of the Phocians by Philip of Macedon, B.C. 346, according to the chronology of Clinton. (*Fasti Hellenici.*)

Sacrifice (Lat. sacrificium). Generally, an offering made to the Deity, whether in token of gratitude, or as a means for obtaining His favour, or averting His wrath, or arresting His vengeance. The sacrifices of all heathen nations fall into two classes, the bloody and the unbloody.

It was the opinion of later Greek writers, such as Plato and Pausanias, that bloody sacrifices were of comparatively late introduction, and that the practice of offering human victims had been preceded by a system which prescribed the presentation of fruits, cakes, and libations. The earlier Greek literature fails to bear out this assertion; and a comparison of their traditions with those of other nations tends to show that the system of human sacrifice was at one time universal, and that the practice had some connection with cannibalism. Achilleus

makes a vow that he will solemnly offer up twelve Trojan youths (*Il.* xviii.) in expiation of the slaughter of Patrocles, and Zeus tells Hera (*Il.* iv. 35) that his wrath would be satiated if she would eat Priam and his children raw. The human sacrifices to Zeus Lycæus in Arcadia seem to have been offered down to the time of the Roman emperors. At Athens two victims were sacrificed, one on behalf of the men, the other on the behalf of the women, at the festival called Thargelia. According to Strabo, a man was thrown every year into the sea from a rock in Leucas in honour of Apollo. The offering of human figures made of rushes in the Lemuralia attests the practice of genuine human sacrifices among the earlier Latins, even if other evidence were wanting in the traditions or the history of later times. The idea that the value and efficacy of the offering was to be measured by the preciousness of the victim was soon developed, and, like Balak in the words of Micah (vi. 7), the parent imagined that he might atone for the sin of his soul by offering up the fruit of his body. The working of this idea is seen in the narrative of the offering of Isaac by Abraham (Stanley, *Lectures on the Jewish Church*), and in the frightful sacrifices of the valley of Hinnom. The inveterate addiction of the Jews to the custom of making their first-born pass through the fire, i. e. of burning them alive in honour of Moloch, is abundantly proved by the constant protests and remonstrances of their prophets. Among the Phœnician tribes the custom prevailed if possible in more horrible excess. During the invasion of Agathocles, the statue of Moloch at Carthage was fed certainly with 200, probably with 500, living children. (Grote, *History of Greece*, part ii. ch. xcvii.)

But in times of which we have historical knowledge, the bloody sacrifices of the Greeks and Romans were generally confined to the slaughter of brute animals. In the earlier times these seem to have been burnt whole [HOLOCAUST]; but in the Homeric ages the legs enclosed in fat, with certain parts of the entrails, were set apart for the gods, while the rest of the carcase furnished a banquet for the worshippers. This change is indicated in the legends of Epimetheus and PROMETHEUS. The gods were supposed to delight especially in the smoke of the sacrifice; hence the potency of the offering was proportioned to the number of the victims, and thus was developed the practice of offering a hundred oxen [HECATOMB], or of a larger number. Whatever may have been their effect on the gods, these sacrifices were undoubtedly acceptable to men as furnishing the means for lavish feastings. The sacrifices of Solomon at the dedication of the temple are said to have furnished the Jews with magnificent banquets for many days. (2 Chron. vii.)

The most common sacrifice of animals among the Romans was the suovetaurilia [LUSTRATION], answering to the Greek τριττύα.

The unbloody sacrifices comprised (1) libations, which especially accompanied the sacrifices offered on the completion of treaties, hence termed σπονδαί; (2) incense; (3) fruit and cakes, the former of these being offered chiefly as first-fruits or tithes of harvest, the latter being peculiar to the worship of certain gods, as of Apollo. These cakes were frequently made in the form of animals, and were then offered as a substitute for the sacrifice of the real animals.

Sacrilege (Lat. sacrilegium). In Roman Law, this crime was defined to be the stealing of sacred things (*sacrarum rerum furtum*), i.e. from a temple. In English Law, the offence of sacrilege is constituted by breaking and entering any church, chapel, meeting-house, or other place of divine worship, and committing any felony therein, or by committing any felony in any such place and then breaking out of the same; and is punishable in the same manner as burglary (stat. 24 & 25 Vict. c. 96).

Sacristan (Low Lat. sacrista). The person to whose charge the vestments used in divine service are committed. The name is now corrupted to *sexton*. In most of the old cathedrals the sacrist was the treasurer's deputy and a vicar choral. (Hook, *Church Dictionary*, s.v.)

Sacristy (Lat. sacer, *sacred*). In Architecture, an apartment attached to a church, in which the consecrated vessels of the church, and the garments in which the clergy officiate, &c., are deposited.

Sacrum (Lat.). In Anatomy, the sacrum is that vertebra, or series of vertebræ, usually anchylosed, which gives attachment to the modified hæmal arch called *pelvic*.

SACRUM. In Anthropotomy, the posterior bone of the pelvis, articulated to the last lumbar vertebra, and firmly united by synchondrosis on each side to the hip bones; below, the os coccygis is attached to it. In young subjects it is composed of five vertebræ united by cartilages, but in more advanced age it becomes one bone.

Sacti. In Hindu Mythology, the female power of the universe, as distinguished from Siva. (Muir, *Sanskrit Texts*, part iv. ch. iii. § vi.) This power is represented in the mysteries of Kali or Durga, the spouse of Siva, by a woman, who receives this title, and is purified for the office in a manner which exhibits the closest resemblance to the rites of initiation in the Eleusinian mysteries. The word is the same as SUTTEE.

Sadder. A work in the modern Persian tongue, comprising a summary of various parts of the ZENDAVESTA, or sacred books of the ancient Persians. The authority and character of the Sadder are supposed to be very small: some attribute it to the Parsees, and give it an antiquity of several centuries; others consider it a more modern forgery. (*Mém. de l'Acad. des Inscr.* vol. xxxviii.)

Saddle (Ger. sattle, Lat. sedile, Fr. selle). In Sea language, a lump of wood acting as a seat or rest to the heel of a boom, and shaped accordingly. It is principally employed in steadying the studding-sail-booms, and the jib-boom.

Sadducees. A sect of religionists among the Jews. It is remarked that during the time of the great Hebrew prophets there is no account of the existence of any sects among them. The most ancient sect was that of the Sadducees, whose founder, Sadok, lived about 250 years B.C. He appears to have restricted the providence of God to the distribution of the temporal rewards and punishments which form the main feature of the old dispensation; and his later followers entirely rejected the doctrine of a resurrection. [SOUL.] They were assimilated also to the Epicureans in maintaining the perfect freedom of human actions; and like those pagan philosophers were few in number, and only of the highest and most literary classes. They were distinguished also from the Pharisees by the rejection of tradition, and by strict adherence to the written law alone. (Milman's *History of Christianity.*)

Safe-conduct (the name as well as usage said to have originated in Italy: *salva condotta*). A license, or passport, from the proper authority, insuring to those who hold it personal safety while passing and repassing from one place to another, over ground occupied by enemies, in time of war. The prerogative of granting it belongs to the sovereign, or the officer in command to whom the sovereign has delegated it. Unless the language be expressly extended, it protects only one person and his *reasonable* baggage. If it be limited as to time, the holder is nevertheless entitled to equitable protection if he has been prevented from returning by some cause over which he has no control. (Phillimore's *International Law*, part ix. chap. viii.)

Safety Lamp. A lamp invented by Sir H. Davy, so constructed as to burn without danger in the explosive atmosphere of coal mines infested with fire damp. Flame may be considered as vapour or aëriform matter in a state of intense ignition; the temperature, therefore, of flame is always very high. Whenever flames emit much light, they derive that property from the presence of finely divided matter diffused through them. Thus, the intense brilliancy of the flame of phosphorus appears to depend upon the particles of incombustible phosphoric acid diffused through it: and the bright light emitted by a gas flame depends upon finely divided charcoal, which is ignited by the gas and at the same time burnt. The correctness of this *theory of flame* is shown by the circumstance of its being extinguished by cooling; and this is best effected by causing it to pass through a piece of fine wire gauze, which, when held horizontally in the midst of the flame, extinguishes its upper part, provided the flame is not projected under pressure, in which case if the pressure be great the flame will pass through. That the wire gauze acts merely by its cooling power, is shown by the flame passing through it when it acquires a white heat, or when its meshes are not fine enough to exert a due cooling power. It is also found that very hot flames, such as that of hydrogen, will pass through tissues impervious to flames of a lower temperature, such as that of a common candle or a gas flame. [FLAME.] The application of these principles to the construction of the safety lamp is as follows: The flame of a small oil lamp C is surrounded by a cylinder of wire gauze A B (doubled at A, where likely to become hottest, and protected by the stout wire frame D), and burns within it, the air having free ingress and egress through the gauze. When it is immersed in an explosive atmosphere, such as that of a coal mine infested by fire damp, the inflammable gas enters from without and burns *in* the cage; but, in consequence of the cooling power of the wire gauze, no flame can pass *outwards* so as to ignite the surrounding atmosphere: the miner, therefore, is warned of his danger by the appearance of the lamp. As long as the external atmosphere is safe, the lamp burns as usual; but upon the approach of the fire damp the flame is more or less enlarged; and in the most explosive condition of the surrounding air the cylinder appears filled with a blue lambent flame, which flickers within it, the wick of the lamp appearing for the time extinguished. It is, however, rekindled as the air becomes more pure; or should the fire damp greatly predominate, it may be entirely extinguished. Before this happens, however, the miner is duly apprised of his danger, and has time to retreat. (Davy *On the Safety Lamp.*)

Attempts have been made to light mines by the electrical light, which not being maintained by combustion may be kept up in an air-tight glass globe. The introduction of effectual means of ventilation into mines has of late received more attention than formerly, by which means accumulation of inflammable gas is prevented; and more attention is also paid to the state of the barometer, the evolution of gas from the coal being found to be in a great degree proportionate to the amount of barometric pressure.

Safety Valve. [STEAM ENGINE.]

Safflower. The *Carthamus tinctorius*, or Bastard Saffron, the dried flowers of which are used as a dye stuff, and in the preparation of the pigment called *rouge*.

Saffron (Welsh safrwn, Ger. and Dutch saffran). The prepared stigmas of the purple-flowered *Crocus sativus*. The stigmas of this species of crocus are of a deep orange colour, and have a peculiar and very characteristic odour; they are used in medicine, chiefly as a rich yellow or orange colouring matter. Saffron is principally imported from the South of Europe, especially Spain; formerly it was largely cultivated in this country in the vicinity of Saffron Walden in Essex. Saffron is often adulterated to a considerable extent with the

petals of other plants, especially with those of the marigold.

Saga (a Teutonic and Scandinavian word, connected with the verb sagen, *to say*). The general name of those ancient compositions which comprise at once the history and mythology of the northern European races. Their language is different from the modern Danish, Swedish, and Norwegian, and is more powerful and expressive than either of these later dialects. Of the mythological sagas the most famous are the saga of Ragnar Lodbrog, the Hervarar saga, the Voluspa saga, and the Wilkina saga. The historical sagas are very numerous; the Jomsvikingia saga and the Kaflinga saga comprehend much of the early annals of Norway and Denmark; the Eyrbiggia saga is the chief historical document of ancient Iceland. Many of them are collected in the great work of Snorre Sturleson called *Heimskringla*. [EPIC; MYTHOLOGY; NIBELUNGEN LIED; SIGURDR.]

Sagapenum. A fetid gum-resin brought from Persia and Alexandria, probably the produce of a species of *Ferula*. It is occasionally used in medicine as a nervine and stimulating expectorant. Its odour somewhat resembles that of assafœtida, but it is much weaker.

Sage. [SALVIA.]

Sageretia (after M. Sageret, a French vegetable physiologist). A genus of *Rhamnaceæ*, of which one species is *S. theezans*, the Tia of the Chinese. It is a native of Penang and the Philippine Islands, as well as of Southern China; and the poorer classes of the Chinese are said to employ its tea-like leaves as a substitute for true tea.

Sagger. A clay used in making the pots in which earthenware is baked, and which are called *saggers* or *seggers*.

Sagging to Leeward. A Nautical term, denoting the movement by which a ship makes considerable lee-way. It is the antithesis to *holding a good wind*, i. e. bearing up well to windward.

Sagitta (Lat. *arrow* or *dart*). One of Ptolemy's forty-eight constellations in the northern hemisphere. [CONSTELLATION.]

SAGITTA. A term used by the older writers on Trigonometry to denote the *versed sine* of an arc; from its resemblance to an arrow standing on the chord of the double arc.

Sagittarius (Lat. *the Archer*). One of the twelve constellations of the Zodiac. It is represented on celestial globes and charts by the figure of a centaur in the act of shooting an arrow from his bow.

Sagittate (Lat. sagittatus, from sagitta, *an arrow*). In Zoology, a part of an animal is so called when it is triangular and hollowed out at the base with posterior angles.

Sago (Malay, sagu, *bread*). A granulated form of starch obtained from various species of Palms and Cycads. The Sago of commerce is prepared from the soft inner portion of the trunks of *Sagus lævis* and *S. Rumphii*, which are sociable palms, growing together in large masses, principally in swampy places. It is obtained by cutting the trunks into pieces about two feet long, the pieces being then split in half, and the soft substance scooped out and pounded in water till the starchy matter separates, when it is drained off with the water, allowed to settle, and afterwards purified by washing. It is then in the form of sago-meal, but before being sent to this country it is made into what is termed ***pearl-sago***. In this process, the rough meal is first repeatedly washed and strained, then spread out to dry, and afterwards broken into small pieces, which, when sufficiently hard, are pounded and sifted until they are of regular size. Small quantities are then placed in a large cloth or bag suspended from the ceiling, and shaken backwards and forwards for about ten minutes, when the particles become granulated or pearled. They are then thoroughly dried and packed for exportation.

Other kinds of Sago are obtained from the stems of *Phœnix farinifera, Corypha Gebanja*, and *Caryota urens*, as well as other Palms and Cycads. What is called Portland Sago is obtained from the corm of *Arum maculatum*, collected in the island of Portland.

Sagum (Lat.). The cloak worn by the inferior officers and the soldiers of the Roman legion, in contradistinction to the PALUDAMENTUM of the generals. It was the dress of war, as the toga was the dress of peace, and was put on by all citizens when there was war in Italy. It was worn open in front, and generally fastened across the shoulder by a strap. This name was also given to the dress of several barbarous nations. Thus Tacitus says of the Germans, *tegumen omnibus sagum*; and Varro and Diodorus Siculus represent it as the costume of the Gauls.

Sagus (Malay sagu, *bread*). The name of the Sago Palm. The word *Sagus* is derived from *Sago* or *Sagu*, which in the language of the Papuan race signifies bread, and is given by them to the two palms from which the well-known Sago of the shops is obtained. [SAGO.] The former of these, *S. lævis* (alias *Metroxylon læve*), from which the greatest part of the sago exported to Europe is derived, grows from twenty-five to fifty feet high, and has a rather thick trunk marked with the scars left by fallen leaves, and usually invested towards the summit with the withered remains of leafstalks; above these the large pinnate smooth-stalked rather erect leaves form a graceful crown, from out of the centre of which the alternately-branched pyramidal flower-spikes arise, their bases being enveloped by smooth sheaths. The latter, *S. Rumphii* (alias *Metroxylon Rumphii*), resembles *S. lævis* in general appearance, but is usually a much smaller tree, and has its leafstalks and the sheaths enveloping the lower part of the flower-spikes armed with sharp spines from half an inch to about an inch long. These trees produce their flower-spikes when about fifteen years old, and the fruit is nearly

three years in ripening, after which they die. In order to procure the greatest quantity of sago, the trees must be cut down immediately the flower-spike make its appearance.

Sahara. The name given to the great desert of the north of Africa, extending from the Nile to the Atlantic coast and from the Atlas mountains to within 10° of the equator. Throughout this vast tract, which is an undulating and for the most part barren district, there are intervals of cultivated land, called Oases. The rest is an ancient sea-bottom, hard, smooth, and level, sometimes covered with sand, and often encrusted with salt. A considerable native traffic is carried on in various directions through the Sahara, and it is thinly peopled throughout with African tribes. With great difficulty and danger, European travellers have at various times succeeded in penetrating to the great central African city of Timbuctu, entering Africa from the north, north-east, south, and west. There is no natural drainage, by river, of any part of the Sahara, and but little rain seems to fall; water is occasionally found in springs and pools, but not during the whole year. The estimated area of the Sahara is two and a half millions of square miles, and the same condition of the surface extends out into the Atlantic, far beyond the African coast. The eastern extremity of the great Sahara, abutting upon Egypt, is covered with a vast accumulation of loose sand drifting eastwards, owing to the prevalence of winds from the west.

Sahlite. In Mineralogy, a greenish-grey variety of Pyroxene or Augite, resembling Diopside, found in the silver mine of Sahla, and in many other parts of Sweden.

Sail (Ger. segel, Dutch zeil). A surface obtained by canvas, mat, or other material, by the action of the wind on which, when extended, the vessel is moved. A sail extended by a yard hung (*slung*) by the middle and balanced, is called a *square sail*: a sail set upon a gaff or a stay, is called a *fore-and-aft sail*; which terms refer to the position of the yard, gaff, or stay, when the sail is not set. The upper part of every sail is the *head*, the lower part the *foot*; the sides in general are called *leeches*; but the weather or side edge of any but a square sail is called the *luff*, and the other edge the *after leech*. The two upper corners are *earings*, but that of a jib is the *head*; the two lower corners are in general *clews*; the weather clew of a fore-and-aft sail, or of a course while set, is the *tack*. The edges of a sail are strengthened by a rope called the *bolt rope*. The ropes at the upper and lower edges are the head and foot ropes of the sail. The canvas or sail-cloth is made in *bolts*; and the qualities are numbered from No. 1, which is the strongest and is used for storm sails, to No. 8, which is used for the smallest sails, as small studding sails, &c., which the seamen commonly call *flying kites*. The cloths in a square sail are seamed vertically; in a fore-and-aft sail they are parallel to the after leech. In this way the strain of the sheet diffuses itself over the canvas both along and across the cloths. Discussions have, however, arisen as to the best mode of seaming. When a seam opens, the sail often splits. Captain Cowan took out a patent for *horizontal* seaming; he remarks (*Essay on the Construction of Sails, &c.*), that such sails when they split remain full, and are less liable to blow away, and that they also were found to last much longer. The plan, however, has not been approved. *Diagonal* seaming, which has also had its advocates, is defective in principle; for it must bring the strain of a sheet either on a single cloth, or entirely across the stitches.

Sails take their names from the mast, yard, or stay upon which they are stretched. Thus, the principal sail extended upon the main mast is called the *main-sail*; the next above, which stands upon the main top-mast, is the *main-top-sail*; above which is the *main top-gallant-sail*; and above all, the *main royal*. In like manner, there are the *foresail*, the *fore top-sail*, the *fore top-gallant-sail*, and the *fore royal*, although the square foresail is very rarely used, from the circumstance that it would take the wind out of all the jibs; and similar appellations are given to the sails supported by the *mizzen* or after mast. The *main stay-sail*, *main-top-mast stay-sail*, &c., are between the main and fore masts; and the *mizzen stay-sail*, *mizzen-top-mast stay-sail*, &c., are between the main and mizzen masts. These are, however, employed only in dead calms and under exceptional circumstances. Between the foremast and bowsprit are the *fore stay-sail* (commonly called the *fore-sail*), the *jib*, and sometimes a *flying jib* and *middle jib*; and the *studding sails* are those which are extended upon booms run out beyond the arms of the different yards of the main mast and fore mast.

To *make* sail, is to set sail. To *shorten* sail, is to take in some sail by furling or reefing. To *loose* sails, is to spread or hang out the sails that had been furled, either to air them, or for the purpose of setting afterwards. To *strike* sail, is to lower the yard or gaff of a sail when set, in token of salute. Furling and reefing sails are performed either by men going along the yard to which the sail's head is attached, and so drawing the sail up and binding it to that yard, or by Cunningham's Patent, described below, under which these operations can be performed from the deck.

The common theory of sails which assumes the impact of columns of air is radically defective; for it is a fact familiar to sailors that the reef points, or any light stuff by accident in the same situation, hang vertically in the hollow of the sail, as in a calm, thereby proving that the sail is filled with a mass of air, quiescent or nearly so, and maintained in a state of statical pressure; whereas if the common theory were true, the points would lie flat to the canvas, as weeds are pressed against the bank of a stream. Hence

it follows that there is a certain extent of hollow or *belly* which increases the effect of the sail. It of course adds to the effect of sails to wet them, by swelling the threads and closing the pores: this practice is often resorted to in calm weather. In recent years several systems have been attempted for furling and taking in sails without the necessity for sending men aloft—a dangerous duty in foul weather. The invention of Mr. Cunningham, R.N., has attained most celebrity. In this, the yard to which the sail is bent is made to revolve in its slings by means of ropes upon the deck, and to wind or unwind the sail upon it. The plan involves a vertical division in the centre of the sail, and, moreover, makes it necessary to lessen the number while increasing the length of the sails on each mast. The practical experience of this system has not yet been sufficient to allow of any decisive opinion on its merits; but, while it is certain to encounter much prejudice from naval men, who cling with singular tenacity to old customs, it is incontrovertible that it saves hands, and therefore diminishes the cost of practical navigation.

Sailing. In Navigation, the art of directing a ship on a given line laid down in a chart. It is called *plane sailing* when the chart is constructed on the supposition that the earth's surface (or rather the surface of the ocean) is an extended plane; and *globular sailing*, when the chart is a globular chart, or constructed on the supposition that the earth is a sphere, the ship being then supposed to be sailing on the arc of a great circle. [GREAT CIRCLE SAILING; NAVIGATION.]

Sailing Order or **Order of Sailing.** Any determinate order preserved by a squadron of ships. It usually implied, in the days of sailing fleets, one, two, or three parallel columns; but it is at the disposition of the admiral.

Sailor. On Shipboard, one who is making a long sea voyage other than his first; and who is qualified to go aloft and tend the sails. A sailor is not necessarily a seaman.

Sainfoin or **Saintfoin** (Fr.). The *Onobrychis sativa*, a plant of the family *Leguminosæ*, and cultivated as a very wholesome fodder. It will not thrive well except when the soil or subsoil is calcareous, and consequently it is rarely met with, except on the Cotswold Hills, and on the chalk soils of Dorset, Hants, Wilts, Sussex, Kent, &c. It generally remains for eight or ten years, a much longer period than it does in France. The first growth is made into hay, the after crop being eaten by cattle; it is also well adapted for *soiling*.

Saint George's Ensign or **The White Ensign.** The distinguishing badge of ships of the Royal Navy. It consists of a red cross on a white field with a union jack in the upper quarter next the mast. The St. George's flag is the admiral's sign of presence and command. An admiral carries it at the main, a vice-admiral at the fore, and a rear-admiral at the mizzen. It resembles the ensign, but is much smaller, and the union jack is wanting.

Saint John of Jerusalem, Knights of. A military order of religious persons. They derived their name from a church and monastery dedicated to St. John the Baptist, founded at Jerusalem about 1048 by merchants from Amalfi, the brotherhood of its members being devoted to the duty of taking care of poor and sick pilgrims. The order was instituted as a military brotherhood by Raymond du Puy, its principal, early in the twelfth century. It was divided into three ranks—knights, chaplains, and servitors; and in its military capacity it was bound to defend the church against the infidels. It held various possessions and settlements in different parts of the East. In the thirteenth century, being driven from Palestine, the knights of this order fixed their principal seat first in Cyprus, and afterwards at Rhodes, where they remained from 1309 to 1522, when the island was captured by Solyman II. After several changes of settlement, they were fixed in 1530 by Charles V. at Malta and its dependent islands; whence they took the name of Knights of Malta. Here they maintained themselves until 1798, when the island was taken by Napoleon. The order, however, continued to subsist, notwithstanding the loss of its sovereign possessions both in Malta and in Tuscany. Before the French revolution the number of knights was estimated at 3,000. The temporal powers of the order were chiefly concentrated in the hands of the grand master; but he was, in fact, controlled by the governors of the eight languages. These were, of Provence, Auvergne, France, Italy, Aragon, Germany, Castile, and England. The lands were divided into priories, commanderies, and bailliages. The spiritual power was exercised by the chapter, consisting of eight ballivi conventuales. The knights were under the rules of the order of St. Augustine; but Protestants were not bound to celibacy. They were required to be necessarily of good descent; but those whose proofs of noble ancestry were unquestionable were termed *cavalieri di giustizia*, while others who could not show such proofs might be admitted on account of their merits as *cavalieri di grazia*. [HOSPITALLERS.]

Saint Simonians. In Political Philosophy, the name given to the followers of Claude Henri, count de St. Simon. [SOCIALISM.]

Saints (Lat. sancti, *holy persons*). Pious men, who, according to a custom early prevalent among Christians, were commemorated with honour after their death in the services and ceremonies of the church. This distinction was originally applied to the apostles and eminent martyrs and confessors, whose places of burial were regarded with pious affection by the faithful in the neighbourhood, and memorials or relics of whom were carefully cherished. The observance of particular days in honour of the saints was also a very early custom, and from this practice the cultus of the saints was

developed. Their intercession was supposed to have power with God, and individuals put themselves under the especial patronage of one or more amongst the number, which in later times was vastly augmented. The assertion that miracles were performed at their tombs and by their relics, led not unfrequently to the greatest rivalry and contention between the votaries of the shrines of different saints, and sometimes those of the same. For the hierarchy of the saints, see Milman, *Latin Christianity*, book xiv. ch. ii. [CANONISATION.]

Saker (for the derivation of this word, see MUSKET). A cannon of the sixteenth century. Tartaglia, who dedicated a work on gunnery to Henry VIII., gives a table of ordnance including 6½-pounder and 8-pounder sakers. Fosbroke (*Encyclopædia of Antiquities*) gives a table of Ordnance of Queen Elizabeth's time, including the saker, throwing a 5¼ lb. ball, and of 3¼ inches calibre. On a gun 7 feet 9 inches long, of 3·75 inches calibre, in the Museum of Artillery at Woolwich, occurs this inscription, 'IHON and Robert Owyn, bretheryn, made thys sacar, weying IZIZ. Anno Dni. 1538.'

Sal Alembroth. The hydrargo-chloride of ammonium. A compound of sal ammoniac and corrosive sublimate.

Sal Ammoniac. Muriate of ammonia; hydro-chlorate of ammonia; chloride of ammonium. A compound of ammonia and hydrochloric acid. Its name is derived from the temple of Jupiter Ammon, in Egypt, where it was originally made by burning camels' dung: it is now largely manufactured in this country. [AMMONIA.]

Sal de Duobus (Lat.). An ancient chemical name applied to sulphate of potash.

Sal Gem. Common salt.

Sal Mirabile (Lat.). Glauber's salt. Sulphate of soda.

Sal Perlatum (Lat.). A term applied by old chemical writers to the rhombic phosphate of soda.

Sal Prunella. Nitrate of potash fused into cakes or balls. The latter were sometimes coloured blue.

Sal Seignette. Tartrate of potash and soda. [ROCHELLE SALT.]

Sal Volatile (Lat.). Carbonate of ammonia. The term is often applied to a spirituous solution of carbonate of ammonia flavoured with aromatics, as in the *compound spirit of ammonia* in the *Pharmacopœia*.

Salade (Fr.) or **Sallet.** A piece of armour for the head, in use in the fifteenth century.

Salamander (Gr. σαλάμανδρα). The name of a genus of Batrachian reptiles, now limited to the terrestrial species of long-tailed Caducibranchiates, or those which lose their gills before arriving at maturity, but retain their tails. This appendage is changed in the progress of growth in the true salamander from a compressed to a rounded form. The female brings forth the young alive, which are hatched in the oviduct; and the sexes frequent the water at the season of reproduction. [BATRACHIA; TRITON.]

Salamstein or **Salamstone.** The name given by Werner to the blue or Oriental Sapphire from Ceylon.

Salep (Arab. Sahleb). The prepared roots of the *Orchis mascula*, *latifolia*, and *Morio*, as well as of other tuber-bearing species of the Orchid family. These roots consist principally of bassorin, with a small quantity of starch, and are dried and preserved for use as an article of food.

Salic Law. The law of that community of the nation of Franks which inhabited the country between the Meuse and the Rhine—the law of the Ripuarian Franks governing those who dwelt between the Rhine and the Loire. The origin of the name Salian, given to this portion of the Franks and their law, is uncertain; some derive it from the river Saale, in Saxony, on the banks of which the Salii are supposed to have been settled before the period of their migration westward. The body of law in question was republished and reformed by Charlemagne in 798, and is still preserved, both in the earlier and in the remodelled shape. The most celebrated portion of it is contained in the title 62. *De Alode*, where it is declared that 'no portion of the inheritance in Salic land (terra salica) can fall to females; but that the whole must pass to the males.' What those lands were which are intended by the term Salic, has afforded room for infinite discussion among French antiquaries. It is supposed by Ducange that they were those lands which were acquired by Franks at the period of the conquest, and held by military service only. But it is argued by some that the exclusion of females was only to take place where males were to be found in the same degree of kindred to the ancestor. However this may be, the fundamental law which excluded females from succession to the crown of France received, in very early times, the appellation of the Salic law, and was supposed by her lawyers to be derived from the provisions of this ancient code. This custom prevailed from the earliest times, as we learn from Tacitus, among the Germanic tribes. The first occasion on which it was publicly canvassed in France was in 1316, when Jeanne, the daughter of Louis Hutin, was excluded from the crown in favour of Philip V. her uncle. In 1328 it was contested by Edward III., who claimed by a title prior to that of Philip of Valois, if females were admissible; Edward being the son of Isabella, sister of Louis Hutin. From this pretension arose the wars between England and France, which occupied the whole of the following century. In 1593 the famous arrêt of the parliament of Paris was pronounced, by which all treaties made to transfer the crown to a foreign dynasty were declared null, as contrary to the *Salic* and other fundamental laws. The same law has been recognised in all countries of which the crown has devolved upon the royal house of France, and formed the foundation of those pretensions of the Infant Don Carlos (Bourbon) to the throne of Spain which caused the

great Spanish civil wars of this century. It was also considered as established in those great fiefs of the crown of France which had been granted to princes of the blood by way of apanage; and by this means, on the death of Charles duke of Burgundy, leaving a daughter only, the dukedom of Burgundy proper reverted to Louis XI. as a male fief. (*Mém. de l'Acad. des Inscr.* vol. xx.; Meyer's *Origines Judiciaires*; Hallam's *Middle Ages*.)

Salicaceæ (*Salix*, the principal genus). A natural order of Achlamydeous Exogens, distinguished by a two-valved capsule, and numerous seeds tufted with long hairs. The genus *Salix* comprehends the plants called Osiers, Sallows, and Willows, and is of great economical value, not only for the purposes of the basket-maker, but because several species have a bark which has been found by Davy to contain as much tannin as the oak. A crystallisable principle called *salicin* has been obtained from *Salix Helix* and others, which, according to Magendie, arrests the progress of fever as efficiently as the sulphate of quinine. The Poplars, Aspens, and Abele trees also form a part of this order.

Salicin (Lat. salix, *a willow*). ($C_{26}H_{18}O_{14}$.) A crystalline substance extracted from the bark of the willow. Its solutions have a bitter taste: they are lævogyrate with reference to polarised light. Salicin is characterised by the deep red colour which is produced when the crystals are moistened with strong sulphuric acid. When salicin is boiled with dilute sulphuric acid, glucose and saligenin are produced. When distilled with bichromate of potash and dilute sulphuric acid, salicylous acid or hydride of salicyl ($C_{14}H_5O_4$, H) is obtained in the distillate. This is identical with the essential oil of Meadow-sweet (*Spiræa Ulmaria*). When fused below redness with three parts of hydrate of potash, a salicylate of the alkali is obtained, from a solution of which salicylic acid is precipitated by the addition of hydrochloric acid. A solution of a *salicylate* is characterised by its striking a *violet*-blue colour with a persalt of iron. Certain insects which feed upon willow bark, oxidise salicin in their bodies; and if placed on paper impregnated with a persalt of iron, and irritated, they eject a liquid which produces a blue spot on the paper. The oil or essence of winter-green (*Gaultheria procumbens*) is a salicylate of the oxide of methyl (C_2H_3O $C_{14}H_5O_5$). It has a strong agreeable odour, and acquires a violet colour on the addition of a persalt of iron.

Salicoques. The French term for the family of Macrourans or long-tailed Crustacea of which the shrimp (*Crangon vulgaris*) is the type.

Salicylic Acid. An acid obtained by the action of fused potassa on salicin. [SALICIN.]

Salient (Lat. salio, *I leap*). In Heraldry, a term used to describe a beast when represented as leaping or springing.

Salient Angle. In Fortification, an angle of which the angular point projects outwards from the work. It is the reverse of a RE-ENTERING ANGLE.

Salient Angle of a Polygon. An angle which projects *outwards*. If an angle of a polygon be defined as the quantity of turning required in order to cause one side to coincide with the next after *sweeping across the polygon itself*, then any angle of a polygon will be *salient* which is less than two right angles; an angle greater than two right angles would then be termed a RE-ENTERING ANGLE.

Salient Places of Arms. In Fortification, enlarged spaces left by the rounding of the counterscarp opposite the salients. They are intended for the assembly of troops for sorties or defence.

Salientia (Lat. part. of salio, *I leap*). The third order in the Mammalogical system of Illiger, including the Marsupial genera *Hypsiprymnus* and *Halmaturus*, or the potoroos and kangaroos, whose progression is by successive leaps.

Saliferous Rocks. Rocks of the Triassic series containing deposits of common salt in England were formerly thus designated. The name is now not generally used, as many of the salt-bearing rocks are Tertiary.

Salifiable Base. This term, which is of frequent occurrence in chemistry, is applied chiefly to those metallic oxides which combine in definite proportions with the acids, so as to form distinct acids. Ammonia and the vegeto-alkalis are also, upon the same principle, salifiable bases.

Salii. The Roman flamens, or peculiar priests of Mars. They were twelve in number, and guarded the ANCILE, or sacred shield of Mars.

Salinometer. An instrument for measuring the quantity of salt that may be in solution in the water of a steam boiler, which is indicated by the specific gravity of the water. Common sea water contains $\frac{1}{33}$ of salt, and the water in the boiler should never be suffered to attain a degree of saturation above that represented by $\frac{2}{33}$ of salt, or *two salt waters* as it is called.

Saliva (Lat.). The fluid secreted into the mouth by the salivary glands; its principal use is to lubricate the parts, and to assist in rendering the food of a proper consistency to be swallowed.

Salivation. The excessive flow of saliva produced by the continuous use of mercury and of some other remedies. Cases of spontaneous salivation have occasionally been noticed, in which the discharge and fœtor have led to the mistaken conclusion that mercury had been used freely.

Salix (Lat. *a willow*). A genus of plants consisting of numerous species, all either trees or bushes, occurring abundantly in the cooler parts of the northern hemisphere. Some, like *S. alba*, acquire the dimensions of the largest forest trees; others are lost among the grass with which they grow, as *S. herbacea*. They are the last kind of ligneous plants that dis-

appear before the rigours of an arctic climate, the only tree found on Melville Island, nine inches high, having been a willow (*Salix arctica*). Few extend into warm regions, the *Salix babylonica*, or Weeping Willow, being the best known instance. Their timber, when they form any, is light, tough, soft, and unfit for purposes of construction; it is chiefly used for turnery, and for coarse in-door purposes. Many species have long flexible shoots, and are called *Osiers*, under which name they are extensively employed by the workers in wicker; others are not flexible, but form small trees or rough bushes, named Sallows. The latter, called *Saules marceaux* by the French, yield the best kind of charcoal for military purposes; they are all, however, burnt for the preparation of this substance. The bark of *S. Helix*, *fragilis*, *pentandra*, and others, has been found useful in intermittent fevers, which are most common in the low marshy places where salices abound. The species intermix very freely, forming mules and hybrids, which have led botanists to create a prodigious number of false species.

Sallow. [SALIX.]

Sally Port. In Fortification, an opening cut in the glacis, through which a passage leads by a ramp from the terreplein of the covered way to the exterior.

SALLY PORT. In Naval language, a landing place in a harbour at which the boats of men-of-war, but no other boats, are allowed to land. It is also the name for the opening in the quarter of a fire-ship by which the crew escape after setting her on fire.

Salmon (Lat. salmo). The excellent and highly valuable fish so called in England is the *Salmo salar* of Linnæus, the *Salmo nobilis* of Pallas. Specimens of this species have been examined, compared, and determined, from French, Danish, Dutch, as well as British rivers, by Dr. Günther, of the British Museum.

The normal locality of the salmon is at the mouth or estuary of the larger rivers, which, in the season of sexual excitement, they ascend, sooner or later in the year, according as circumstances may influence their coming into breeding condition. At first they ascend only so far as the tide wave reaches, and retire with the ebb; but as the quantity of roe and milt increases, the instinct which teaches the fit locality for oviposition becomes more imperative, and there are few natural obstacles which the salmon fails to overcome in its endeavour to reach it.

The great value of the fish renders an accurate knowledge of it, under the disguise of its immature form and markings, of the highest importance; but the difficulties which attend the observation of the migratory inhabitants of the water have only very lately been overcome in the present instance. The proof that the small salmonoid fish, called the *parr*, is, as many naturalists had suspected, the young of the salmon, has been elicited by the careful and repeated observations and experiments of Mr. Shaw of Drumlanrig, of which the following condensed account is taken from the *Transactions of the Royal Society of Edinburgh*.

In the river Nith, Dumfries, the salmon oviposits in the month of January. On January 10, Mr. Shaw observed a female salmon of about 16 lbs. weight, and two males of at least 25 lbs., engaged in depositing their spawn. The spot which they had selected for that purpose was a little apart from some other salmon which were engaged in the same process, and rather nearer the side of the stream, although still in pretty deep water. The two males kept up an incessant conflict during the whole of the day for possession of the female, and in their struggle frequently drove each other almost ashore, and were repeatedly on the surface, displaying their dorsal fins and lashing the water with their tails.—The female throws herself at intervals of a few minutes upon her side; and while in that position, by the rapid action of her tail she digs a receptacle in the gravel for her ova, a portion of which she deposits, and again turning upon her side she covers it up by the renewed action of the tail; thus alternately digging, depositing, and covering the ova, until the process is completed by the laying of the whole mass, an operation which generally occupies three or four days. The embryo fish, conspicuous by the two dark eye-specks and the vascular vitelline sac, presented some appearance of animation in the ovum on February 26, i. e. forty-eight days after having been deposited; and on April 8, or ninety days after impregnation of the ova, the young were excluded. The head is large in proportion to the body, which measures five-eighths of an inch in length; the vitellicle is two-eighths of an inch in length, and resembles a light red currant; the tail is margined like that of the tadpole, with a continuous fin running from the dorsal above to the anal beneath. The vitelline sac and its contents are absorbed by May 30, or in about fifty days, until which time the young fish does not leave the gravel. The terminal fringe-like fin now begins to divide itself into the dorsal, adipose, caudal, and anal fins; and the transverse bars on the sides of the body make their appearance. At this period the young salmon measures an inch in length, and is very active, and continues in the shallows of its native stream till the following spring, when it has attained the length of from three to four inches, and is called the *May parr*: they now descend into deeper parts of the river, where the weaker fish remain over the second winter. In April, the caudal, pectoral, and dorsal fins assume a dusky margin; the lateral bars begin to be concealed by a silvery pigment; and the migratory dress, characteristic of the salmon fry or smolt, is assumed. The fish now begin to congregate in shoals, and to migrate seaward. They return in autumn of a size proportionate to the length of their stay in the estuary. A smolt may not exceed two ounces weight when it goes to sea; after a few months it may have grown to a *grilse* of eight or ten pounds weight. At two

years and eight months old, it becomes a *salmon* of from twelve to fifteen pounds weight.

The full-grown salmon averages a weight of between 25 lbs. and 35 lbs.; but instances are recorded of their attaining to 55 lbs., 60 lbs., 70 lbs., 74 lbs., and 83 lbs. The last-cited weight was that of a female salmon, which came into the possession of Mr. Groves, fishmonger, in Bond Street, about the season of 1821; it was a short fish for the weight, but of very unusual thickness and depth. When cut up, the flesh was fine in colour, and proved of excellent quality. [FISHERIES.]

Salmonoids. A family of soft-finned Abdominal fishes, of which the salmon is the type, having their upper jaw formed in the middle by the intermaxillary, and at the sides by the maxillary bones, both of which support teeth; they are also characterised by a posterior small adipose dorsal fin, and the body is covered with regular cycloid scales. They pass, by almost imperceptible gradations, into the Clupeoid or herring family, with which they have been united by M. Agassiz, to form a common group termed *Halecoids*. Those species of Salmonoids which, like the Clupeoids, inhabit the sea, not only approach the land, but ascend the rivers nearly to their source, in order to deposit their ova.

Saloon (Ital. salone). In Architecture, a large state apartment; or a great hall, usually running up through two stories of a house. The term *salon* is also applied to the réunions of the French capital.

Saloop. [SASSAFRAS.]

Salop. [SALEP.]

Salp (Lat. salpa, *a stock-fish*). A name applied to a genus of soft-shelled or tunicated Acephalous Molluscs, which float in the sea, protected by a transparent gelatinous coat, perforated for the passage of water at both extremities.

Salpinx (Gr. σάλπιγξ, *a trumpet*). The Eustachian tube, or channel of communication between the mouth and ear.

Salsafy. The *Tragopogon porrifolius* of botanists, the fleshy roots of which form a wholesome and nutritious esculent. The plant is a biennial, indigenous to Britain and the continent of Europe, and has a long fusiform root, full of milky juice, on which its salutary qualities depend. In colour it resembles the parsnip, of which it has also nearly the flavour, but is more agreeable. It ranks as one of the most salubrious of culinary vegetables, being antibilious, cooling, deobstruent, and slightly aperient; but although it is deservedly esteemed as excellent, it is nevertheless inferior to *Scorzonera* in these properties.

Salsola (Lat. salsus, *salt*). A genus of *Chenopodiaceæ*, the species of which are distinguished by the name of Saltworts. They are found only on the sea-coast or in salt marshes, and are of weedy character; but the ashes of some of them, e.g. *S. Kali* and *S. Soda*, yield an impure carbonate of soda known under the Spanish name *Barilla*, which was formerly an article of considerable commercial importance. Large quantities of it were at one time annually imported into the United Kingdom from the Canary Islands, Spain, and other parts of the South of Europe, and employed in soap and glass-making; but since the introduction of soda manufactured from common salt as a commercial article, the imports have greatly decreased, though about a thousand tons of barilla and other alkalies are still annually imported, mostly from the Canary Islands and the Two Sicilies. For the preparation of barilla these plants are dried in heaps like hay, and afterwards burnt upon a rude grating constructed over a large hole, into which the semifluid alkaline matter flows, and is there left to cool and solidify. *Kali* is the Arabic name for the ashes of these soda-plants, and the term *alkali*, applied by chemists to soda, potassa, and similar substances, appears to be derived either from *Kali*, with the Arabic article *al* prefixed or from a corruption of *sal* (salt) and *Kali*.

Salt (Lat. sal, Ger. salz, Gr. ἅλς). This term, though in ordinary language limited to common salt, or sea-salt, is applied in chemistry to all combinations of acids with alkaline or salifiable bases. The term has also been extended to certain binary combinations of chlorine, iodine, bromine, and fluorine with the metals; and these have been called *haloid salts*, inasmuch as modern chemistry has taught us that sea-salt belongs to this class. Certain definite combinations of the sulphides with each other have been called *sulphur salts*; but the appellation of *double sulphides* is more commonly applied to such compounds.

Sea-salt is a compound of one equivalent of sodium = 23, and 1 of chlorine = 35·5; its equivalent, therefore, is (23 + 35·5) = 58·5: and it is a chloride of sodium. The circumstances which gave rise to the notion of its containing muriatic acid and soda, and being therefore a muriate (hydrochlorate) of soda, will be apparent by reference to the article MURIATIC ACID.

Salt is a necessary of life, and one of the most important British minerals. It is procured in immense quantities, both from fossil beds and brine springs, in Cheshire and Worcestershire. Before the discovery of the fossil beds during the sixteenth century, and subsequently, a good deal of salt continued to be made by the evaporation of sea-water in salt-pans, at Lymington and many other places; but the works at these places are now all but abandoned; while not only has the quality of salt become greatly improved, but, instead of being imported as formerly, it is now largely exported. The consumption of Great Britain alone, exclusive of Ireland, amounts to about 180,000 tons; the foreign exports amount to about 300,000 tons per year, of which the United States, Canada, the Low Countries, Russia, Prussia, and Denmark are the chief consumers. Down to the year 1823, a tax of 15*s*. per bushel, or about thirty times the original cost price of the article, was imposed on salt; but in that year it was reduced to

2s., and two years subsequently was totally repealed. During the existence of the duty, the retail price of salt was 4½d., it is now ½d. per lb.

In ancient Rome, salt was subjected to a duty, *vectigal salinarium*; and it has been heavily taxed in modern states. The GABELLE, or code of salt laws formerly established in France, was most oppressive. From 4,000 to 5,000 persons were calculated to have been sent annually to prison and the galleys, for offences connected with these laws, the severity of which had no inconsiderable share in bringing about the revolution.

Salt Deposits, Salt Springs. Very large accumulations of salt occur in certain rocks without reference to geological age. They are, for the most part, distributed in very limited areas. The principal salt deposits in England are in Cheshire and adjoining counties, in beds of the new red sandstone series. In the Tyrol there are large deposits, of similar geological age. At Cardona, in Spain, in the lower tertiary rocks, is a magnificent developement of rock-salt, and in Poland and Hungary there are enormous masses, of middle tertiary age. Salt springs are common in carboniferous rocks, both in England and America. In other places, as in the Dead Sea, there is salt now in course of deposit.

Salt is usually associated with marls, sandstones, and gypsum, and appears to have been generally accumulated by the evaporation of sea-water, which contains a quantity of materials left behind under such circumstances. The salts collect, and in course of time many of them enter into new combinations; that which is most valuable to man, the chloride of sodium, forming into beds and rocky masses.

Afterwards, if water obtain access to such beds, they are partially dissolved, and the water may come to the surface as brine springs, which are not unfrequent where rock-salt is not known.

Salt Gardens (Fr. salins). A name applied to the evaporating surfaces employed on the south and west coasts of France for the preparation of common salt from sea-water. They are also called *salterns*. The salt gardens are usually erected close to salt marshes, which are kept filled by the sea. The marshes act as a reservoir for the salt gardens, and also possess the advantage of concentrating the saline water by spontaneous evaporation. During the summer months the water from the marshes is allowed to flow very slowly, and in layers not more than five or six centimètres deep, over a number of square basins. The current of water is so regulated that when it arrives at the last of these basins it is on the point of crystallising; it is then run into smaller basins, where the chloride of sodium is deposited. After the chloride of sodium has been separated, the mother liquors are employed for the preparation of chloride of potassium, chloride of magnesium, sulphate of magnesia, and sulphate of soda. Salterns were formerly common along the south coast of England, where a few may still be seen in operation.

Salt Lakes. In the article on the DEAD SEA an account is given of the very remarkable depressed salt lake system of Palestine. It is not, however, necessary that a lake should be depressed below the sea level to be thus loaded with salt. The lake of Oroomiah, in the north-west of Persia, eighty miles long and thirty miles broad in some places, is nearly 4,000 feet above the level of the Black Sea. This is also a salt lake, but nearly the whole saline contents are common salt, and there remain in the water both sulphate of lime and sulphate of magnesia. In this case, however, the salt is derived from the soil, and not deposited upon it; the whole surrounding neighbourhood, which is flat, abounding everywhere with rock-salt. These deposits of rock-salt, perhaps originally produced like those of the Dead Sea, are now being redissolved by fresh water poured over them periodically and draining into this lake, from whose surface a large and constant evaporation takes place.

The Elton lake, connected with a group of very important brine pools in the lowest part of the great depression of the Aralo-Caspian plains, is another example of the formation of rock-salt, closely resembling the Dead Sea. This lake measures thirteen miles by eleven, or thereabouts, and is nineteen feet below the sea level; but it is part of a very wide tract of country, nearly flat, in which are a vast multitude of smaller lakes, also loaded with salt. Its waters vary much in contents in different parts of the year, especially in the proportion of common salt, but there is always from 10 to nearly 20 per cent. of chloride of magnesium. This is therefore a concentrating mother liquor depositing salt regularly every summer, and receiving other additions in other parts of the year. Here, as in the Dead Sea, a regular deposit is going on, which is not, however, so calculated to produce continuous and thick beds of rock-salt, although in course of time, when the proportion of the chloride of magnesium is larger (and it is constantly increasing), the result will be a much more rapid deposit of common salt, and the accumulation in the mother liquor of similar mineral ingredients.

There is no need to give the history of other depressed or elevated salt lakes, in order to show that the production of salt beds in the one case, or their consumption in the other, is the consequence of laws which, acting from time immemorial, have added continually to the mineral wealth of many parts of the world.

Salt of Lemons. Binoxalate of potassa is usually sold under this name, and is used for the removal of iron-moulds and other stains from linen.

Salt Mines. The deposits of rock-salt in the county of Cheshire in England, and in various parts of the continent of Europe

and elsewhere, are often capable of extraction by simple modifications of the ordinary processes of mining. Salt is also largely obtained from brine springs whose source is in deposits of similar kind. The methods of mining vary naturally according to the circumstances of the deposit.

The salt mines of Cheshire are intended to remove the salt from two irregular masses, whose thickness is in some places as much as a hundred feet. These masses are parts of a large group of saliferous marls and sandstones, whose area is not less than 150 square miles, but the thick deposits are very much smaller. These deposits are in the Triassic series. Others of the same nature occur at Cardona, near Barcelona in Spain, others in the Tyrol, others in Poland, and all these are in similar marls and sandstones. The method of working closely resembles that adopted in removing thick coal. [MINING.] In the Tyrol, large cavities in the salt-bearing rocks are filled with water, which is allowed to become saturated, and is then pumped off and evaporated.

Salt of Sorrel. A name frequently applied to the binoxalate of potash. [OXALIC ACID.]

Salt, Spirit of. [MURIATIC ACID.]

Salts. The term *salt*, as a noun, originally belonged to common sea-salt only. Domestically it does so still. In Chemistry, it is now conventionally applied to any well-defined solid substance containing two or more radicals. The radicals may be simple or compound, inorganic or organic. *Haloid salts* contain two simple inorganic radicals, as in chloride of sodium and iodide of potassium. *Oxysalts* consist of two compound organic or inorganic radicals which contain oxygen, as in sulphate of quinine or nitrate of potash. *Sulphur salts* are oxysalts in which oxygen is replaced by sulphur, as the sulpharsenite or sulphide of sodium. *Supersalts* are those containing excess of negative constituent, as superphosphate of lime.

Saltatory (Lat. saltatorius, from salto, *I leap*). In Zoology, the extremities of an animal which by their form and proportions are adapted for leaping, are called *pedes saltatorii*; as the hind legs of the kangaroo, cricket, &c.

Salterus. [SALT GARDENS.]

Saltigrades (Lat. saltus, *a leap*, and gradior, *I walk*). The name of a tribe of spiders which seize their prey by leaping upon it from a distance.

Saltire (Fr. sautoir). In Heraldry, an ordinary in the form of a cross of Saint Andrew: formed by two bends, dexter and sinister, crossing each other. Charges having length (swords, bâtons, &c.) placed in the direction of the saltire, are said to be borne *saltire-wise*.

Saltpetre. [NITRE.]

Salute (Lat. saluto, *I greet*). In the Military and Naval services, a mark of respect performed in different ways, according to circumstances. Salutes are fired from cannon according to instructions laid down in the Queen's regulations. The number of guns marks the rank of the personage saluted. A royal salute consists of twenty-one guns. Ambassadors are saluted with nineteen guns; and so the number decreases, to the salute for consuls, captains of the navy, &c., which is of seven guns. A foreigner's salute is returned gun for gun.

Troops under arms salute with their rifles or swords; staff officers not drawing their swords salute with the hand, as do soldiers when unarmed. The theory of the salute is founded probably on the temporary disarmament of the person saluting. Thus, in the naval salute, the discharge of the guns renders the ship for the time helpless; and in the military salute each of the various movements disqualifies the performer both for attack and defence.

Salvadoraceæ (Salvadora, one of the genera). A small natural order of Perigynous Exogens, of the Echial alliance in Lindley's arrangement. The few known species are found in India, Syria, and North Africa; and the group is specially known by its regular symmetrical flowers, its naked stigma, and its solitary fruit. The most interesting plant of the order is *Salvadora persica*, which according to the researches of Dr. Royle is the Mustard-tree of the New Testament. This view, however, is not universally adopted, some distinguished botanists of the present day regarding it as more probable that our common black mustard, which attains considerable size in Palestine, is the plant referred to in the Gospels.

Salvage (Fr. from Lat. salvus, *safe*). In Mercantile Law, salvage is defined to be a compensation to be made by the shipowner or merchant to other persons by whose assistance the ship or lading may be saved from impending peril, or recovered after actual loss. Salvage may become due: 1. On rescue from the perils of the sea. In this case, the salvor, or rescuer, has a lien on the goods preserved until a recompense is made him. The amount of this recompense may be fixed by a jury; but if the salvage happen at sea, or between high and low water mark, the court of admiralty has also jurisdiction to fix the amount on suit brought; and by statute, summary powers for the same purpose are given to inferior officers in certain cases. 2. On rescue from the hands of enemies. In this case, the old law was, that if a ship was retaken from enemies before it was taken home or condemned by the captor, the original owner could recover her on payment of salvage to the recaptor; but if retaken at a later period, she became lawful prize to the recaptors. But by 13 Geo. II. c. 4, s. 18, and other statutes, the right of the original owner has been extended to all cases of recapture. See now 17 & 18 Vict. c. 104, and 18 & 19 Vict. c. 91.

Salvatella (Lat. salvus, *safe*). A vein of the arm terminating in the fingers. It was

formerly regarded as having peculiar influence on the health when opened.

Salvia. A genus of useful as well as ornamental plants, belonging to the Labiate order. Many of the species, as *S. splendens, cardinalis, gesnerifolia, patens,* and others, are extremely showy greenhouse plants; and some, as *S. hians, candelabrum, pratensis,* &c., are gay, hardy perennials. *S. officinalis* is the well-known garden herb, called Sage, cultivated everywhere for its bitter and aromatic properties.

Sama Veda. [Veda.]

Samanæans. A sect of Indian philosophers. The name is probably Oriental; the word schamman, in India, signifying a philosopher. The Samanæans are particularly distinguished, by those who mention them, from the Brahmans. Saint Jerome and Clement of Alexandria represent them as priests of Buddha; and the same name appears in the *Cha-Men* of the Chinese, and *Sammono-Codom* of Siam. [Buddhists.] There is a memoir on the subject by M. de Guignes. (*Mém. de l'Acad. des Inscr.* vol. xxvi.; *Hist. de l'Acad. des Inscr.* vol. xxxi.; and *Mém.* vol. xl.)

Samara (Lat. *an elm-seed*). In Botany, an indehiscent superior fruit, being a few-seeded, dry nut, elongated into wing-like expansions; as in the fruit or *key* of the ash-tree, &c. From this root is formed the word *samaroid*, expressing a resemblance to a samara.

Samaritans. The inhabitants of the city and district of Samaria to the north of Judea. This city, built by King Omri, was the capital of the kings of the ten tribes of Israel. After these had been carried into captivity, it is believed by some that a new population became gradually settled in Samaria, composed partly of a remnant of the old, partly of strangers; by others, that the country was entirely desolated, and that Esarhaddon settled it anew with strangers, especially Cuthites, thought to be of Scythian origin, who afterwards learned the Jewish religion. The Samaritans thus formed a kind of mixed nation, adopting to a great extent Jewish belief and practices. They professed belief in the Pentateuch, but they maintained that Abraham and Jacob had erected an altar on Mount Gerizim in their country, and commanded sacrifice to be made there. Nevertheless, no idolatrous practices are imputed to them; and it was probably their spurious origin which excited against them the jealousy and affected contempt of the Jews, to which many passages of the New Testament so pointedly refer.

Samarskite. A rare mineral composed of a mixture of niobic acid, and small quantities of tungstic acid and various bases, chiefly peroxide of uranium, yttria, zirconia, and protoxide of iron. To these last Thorina has lately been added by the analyses of Finkener and Stephens. It is found in flattened and somewhat polygonal grains which are externally dull iron-black and opaque, in the Ilmen mountains near Miask, in the Ural embedded in reddish-brown Felspar. Named after M. von Samarski.

Sambuca (Lat.; Gr. σαμβύκη). An ancient instrument, resembling a harp, the invention of which was attributed to the Syrians and Phœnicians.

From the likeness to this instrument, the name was also applied to a military engine used in scaling the walls of besieged cities.

Sambucus (Gr. σαμβύκη, *an ancient musical instrument*). A genus of *Caprifoliaceæ*, well represented by the Common Elder, *S. nigra*, a tree of rapid growth when young and remarkable for the stoutness of its shoots, which contain an unusual proportion of pith. This being easily removed, the branches may readily be formed into tubes, and on this account the elder was formerly called the Bore-tree. The wood is white and of a close grain, tough, fissile, and easily cut—hence it is used for making skewers and shoemakers' pegs. The leaves have an unpleasant odour when bruised, which is supposed to be offensive to most insects, and a decoction of them is sometimes employed by gardeners to keep off caterpillars from delicate plants. By village herbalists they are employed in making a kind of ointment, and the flowers serve for fomentations, or are made into a medicinal tea; while the berries are the principal ingredient in *elderberry wine*. *S. Ebulus*, or Danewort, is a herb with a nauseous smell and drastic properties.

Samian Earth and Stone. A species of Bole or marl from the island of Samos.

Samp. A preparation of Indian Corn, largely used in the United States.

Samphire (said to be a corruption of Fr. Saint Pierre). The *Crithmum maritimum* of our coasts, the aromatic fleshy saline leaves of which are collected and made into pickle.

Samson's Post. A strong pillar resting on the keelson, and supporting a beam of the deck over the hold, thus helping to keep the cargo in its place. Also a temporary or movable pillar carrying a leading block for various purposes.

Samuel, Books of. Two canonical books of the Old Testament. The first twenty-four chapters of the first book contain all that relates to the prophet Samuel himself, beginning with the government of Eli. The second book, together with the remainder of the first, carries on the history of the Jews to the death of David. It is traditionally said that the prophet Samuel composed the first part, and the prophets Gad and Nathan the remainder. In early times, these two, and the two following books of the Old Testament, were comprehended under the general name of the Four Books of Kings.

Samydaceæ (Samyda, one of the genera). A small order of Hypogynous Exogens, placed by Lindley in the Violal alliance. It possesses slightly astringent properties, and the species of *Casearia* are used medicinally in South America. The plants have dotted leaves, and apetalous hermaphrodite flowers.

Sanchuniathon (Gr. Σαγχουνιάθων). A writer stated by Philon Byblius to have been

born in Berytus and to have lived in the time of SEMIRAMIS; but as Semiramis herself is mythical, this statement does not furnish much evidence for the existence of Sanchuniathon, in which few now will be found to believe. For the motives which probably moved Philon to forge the fragments which go by the name of Sanchuniathon, see Smith's *Dictionary of Greek and Roman Biography*, s.v.

Sanctification (Lat. sanctificatio). In Theology, this word is employed to denote the state of those Christians who, having lost the inclination to vice, have become pure and holy. This state is produced by the special operation of the Holy Ghost, and ensues upon JUSTIFICATION.

Sanctuary (Lat. sanctuarium, from sanctus, *holy*). The innermost chamber of the tabernacle, or temple, among the Jews, in which was kept the ark of the covenant, and which was regarded as the especial residence of the Most High. It is also called the *holy of holies*, and was never entered except once a year, and then only by the high priest on the day of the great expiation of the sins of the people. For the mystical signification of this act, see Heb. ix. 24.

In Christian churches, the part immediately round the altar is called the *sanctuary*, which is supposed in many respects to bear an analogy to that of the Jews.

From the time of Constantine downwards, certain churches have been set apart in many countries to be an asylum for fugitives from the hands of justice. This seems to have been originally intended only to prevent sudden violence, and to give time for the regular administration of the law, and perhaps, in the case of certain delinquencies, for the intercession of the church. But in England, particularly down to the Reformation, any person who had taken refuge in a sanctuary was secured against punishment, if within the space of forty days he gave signs of repentance and subjected himself to banishment. [ASYLUM.]

Sand (A.-Sax. and Ger.; Dutch zand). Finely divided silicious matter constitutes common river and sea-sand. Particles of other substances are often blended with it, and sometimes it becomes calcareous from the prevalence of carbonate of lime. Silicious sand, selected for the manufacture of mortar and other cements, should be freed from all saline matters, not too fine-grained, and somewhat sharp or angular. In the manufacture of glass and of porcelain it should be free from oxide of iron, and other tinging oxides. The fine white sand resulting from the disintegration of soft and pure sandstone is much used, under the name of *silver*-sand.

Sand Pipes. Deep hollows of cylindrical form and very narrow are frequently found penetrating the surface of chalk, and filled with sand and gravel. They are called in Norfolk, where they are most common, sand pipes or sand galls. In France they are known as *puits naturels*. They have been found near Norwich penetrating upwards of sixty feet into the chalk, the larger ones being twelve feet in diameter. They all taper downward and end in a point, and even when close together, and in soft chalk, the walls are not broken through. Generally the sides and bottom are lined with clay, and the central part of each pipe is full of sand and gravel.

It is not easy always to see how such pipes or funnels can have been found. Some may have commenced by the rotatory motion of stones drilling holes in the chalk, but they have probably been continued by the slow action of water containing carbonic acid penetrating into holes made in this or some other accidental way, and perhaps deepened in modern times by the action of humic acid derived from the roots of trees penetrating down and afterwards decaying.

It is not unfrequently the case that the course of a sand pipe can be traced through the gravel and sand overlying it by its effect on the vegetable soil.

Sand Shot. In Artillery, small cast-iron balls; so called because they have always been cast in sand, while the larger shot used to be cast in iron moulds. They are used for grape and case, or are fired loose from a mortar.

Sandal Wood. The name of various odoriferous woods obtained from the genus *Santalum*. These woods formerly bore the name of Sanders Wood. White or Indian Sandal Wood comes from *S. album*; Yellow or Sandwich Island, from *S. Freycinetianum* and *S. paniculatum*; while Western Australia furnishes another kind in the wood of *S. latifolium*. What is called Red Sandal Wood is another thing, and is produced by *Pterocarpus santalinus*.

Sandals (Gr. σάνδαλον). A species of slippers worn by the ancient Jews, Greeks, and Romans. They consisted of a sole with a hollow part at one end, to embrace the ankle and leave the upper part of the foot bare. Originally sandals were made of leather; but they afterwards became articles of great luxury, being made of gold, silver, or other precious stuff, and beautifully ornamented.

Sandarach (Gr. σανδαράκη, *realgar*). A white brittle resin obtained from *Callitris quadrivalvis*. The powder of this resin is sometimes used, under the name of *pounce*, to prevent ink from sinking into paper. [CALLITRIS; JUNIPER.]

Sandbags. In Military operations, bags of coarse canvas filled with sand, much used in cases where cover for troops is required to be speedily obtained, as a temporary revetment for parapets, &c.

Sandbox-tree. The West Indian name for *Hura crepitans*.

Sandemanians. In Ecclesiastical History, a name given in England to a small body of Christians, who are termed Glasites in Scotland. In 1727, John Glas, a minister of the church of Scotland, published *The Testimony of the King of Martyrs concerning His Kingdom*

(John xviii. 36), in which he opposed national establishments, and described the Christian church with its doctrines, practices, officers, and discipline, as set forth in the New Testament. Having been deposed in 1728, he formed his followers into churches after the primitive models. In 1755, the publication of a series *of letters* by his son-in-law, Robert Sandeman, led to the formation of similar churches in London, and other places in England, and also in America, several of which still exist. The Sandemanians do not recognise the name given to them, and profess to hold no doctrines or observe any precepts but what are clearly enforced in the New Testament.

Sanderling. The name of a small wading bird, a species of *Tringa* (*Tr. arenaria*, Ill.), which frequents many of our shores, but not in great numbers.

Sanders Wood. [SANDAL WOOD.]

Sandiver. The impurities which collect upon glass during its fusion in the furnace are so called.

Sandpiper. A name applied to different species of the genus *Tringa*, but properly restricted to the *Tringa hypoleucus* of Linnæus, which is the type of the subgenus *Totanus*.

Sandstone. One of the three great divisions of the sedimentary rock masses, limestone and clay being the others. In Geology, sandstones belong to all geological periods, and exhibit almost infinite variety of detail, although with a degree of general resemblance not easily mistaken. They are mixed in all proportions with calcareous and argillaceous matter, thus passing into marls and loams, and forming vegetable soils. They sometimes contain so much oxide of iron as to pass into ironstones. Existing sometimes, quite uncemented, as loose sand, they also exhibit all degrees of cementation till in quartz rock or quartzite they are perfectly compact and have lost all granular texture.

Sandstones are presented in no regular order. Large tracts of country consist almost exclusively of such rock, and are very barren, but more usually other rocks alternate with them, and the mixture makes vegetable soil.

Sandstones are rarely fossiliferous. They are, however, remarkable as a group containing a peculiar kind of fossil, namely the imprint of animals that have walked over certain beds while the mass was being accumulated and before the sea-sand had passed into the state of stone. Such footmarks have been detected chiefly in the older secondary sandstones, especially the new red sandstone; as in the neighbourhood of Liverpool and in Warwickshire in England, in some parts of Scotland, in Connecticut and other northern states of America. They have been found much more sparingly in the Palæozoic sandstones. In all these cases the conditions under which the footmark has been left were probably similar. [FOOTPRINTS, FOSSIL.] In this kind of rock not only the deep footprints of large animals, but very small scratchings of crabs and worms, and probably other creatures, the marks of rain recently fallen, and the forms of seaweed have also been found accurately recorded.

Sandstones are valuable for building purposes. Some, especially those of which the cementing medium is silica, are extremely durable; others, cemented only by carbonate of lime or oxide of iron, are so rotten as not to be worth the expense of moving from the quarry. There are many intermediate qualities.

Many of the fine grits from the coal measures, with a little mica distributed through them and coloured with carbon of a faint grey, are both durable and easily worked. [BUILDING MATERIALS.]

Sandstones of which the particles are coarse, are called GRIT, and when made up of pebbles cemented together they are termed CONGLOMERATE or PUDDING STONE.

Sandwort. The common name for the weedy native genus of plants called *Arenaria*.

Sandyx (Gr. σάνδυξ). An old Alchemical term applied to red lead prepared by calcining carbonate of lead.

Sangiac. A Turkish officer, governor of a sangiacate, or district forming part of a pashalic. There were 290 such districts in the Turkish empire before the losses of territory on the side of Greece and the Caucasus. [PASHA.]

Sangreal or **Saint Graal** (the Holy Cup or vessel, said to be from Mod. Lat. gradale, *a cup*; but supposed by some to be a corruption of the Old French, le Sang Real, i.e. *the true blood* of Christ). This sacred relic, preserved in an emerald cup, is said in legendary history to have been brought to England by Joseph of Arimathæa. According to the romantic story of King Arthur, it could only be discovered by one possessed of perfect virtue; and the 'quest of the St. Graal' by the Knights of the Round Table, of whom the perfect champion, Sir Galahad (in other legends Perceval), was favoured by its discovery, is narrated therein at great length. [ROUND TABLE.]

Sanguinaria (Lat. Sanguinarius, from sanguis, *blood*). A genus of *Papaveraceæ* of some medicinal repute, common in the United States, and consisting of one species, *S. canadensis*, which bears the popular names of Puccoon and Blood-root, from the coloured juice present in the roots.

Sanguisorbeæ (Sanguisorba, one of the genera). An order or sub-order of herbaceous or undershrubby Exogens, usually combined with *Rosaceæ*, but sometimes regarded as distinct, on account of the constantly apetalous flowers, indurated calyx, and solitary or almost solitary carpels. Their general character is that of astringency. The *Sanguisorba officinalis*, or Burnet, is sometimes grown as a pasture plant.

Sanguisuges (Lat. sanguis, *blood*; sugo, *I suck*). The name of a family of Hemipterous insects, including those which suck the blood of animals: also applied to a family of Abranchiate Annelides, of which the leech (*Sanguisuga medicinalis*, Sav.) is the type.

Sanhedrim. The highest judicial tribunal among the Jews, consisting of seventy-one members, including the high priest. Its origin is referred by some writers to the institution by Moses of a council of seventy persons on the occasion of a rebellion of the Israelites in the wilderness. (Milman's *Hist. of Christianity*, i. 339, &c.)

Sanidine (Gr. *σανίς, a board*). A name given to Glassy Felspar, on account of the tabular form of its crystals. It is a transparent or translucent variety of Potash Felspar, white or of a greyish colour, with a very bright vitreous lustre, and occurs only in volcanic rocks.

Sanies (Lat.). A thin unhealthy discharge from wounds or sores.

Sans-culottes (Fr. *breecheslesss*). A name first given in ridicule to the Jacobins and other extravagant patriots in the French Revolution, and afterwards assumed by them as a title of honour; like the old nickname of *gueux* (*beggars*), in which the revolters of the Netherlands prided themselves. Camille Desmoulins appears to have been one of the first who rendered it popular, his blasphemous application of it at his trial is well known. It acquired great celebrity after the *journée* of the 20th June, 1792, when one of the principal standards borne by the insurgents was a pair of black breeches, with the inscription, 'Tremblez, tyrans! voici les Sans-Culottes.' Subsequently the French nation adopted it with the utmost gravity in the original Republican calendar. The five supernumerary days (the twelve months containing thirty a piece) were named Sansculottides; and were festivals dedicated to 'Genius,' 'Labour,' 'Actions,' 'Rewards,' 'Opinion.' In Leap years there was to be a sixth Sansculottide, the festival of the Revolution.

Sanscrit. The learned language of Hindustan, which had ceased to be a spoken language at least 300 B.C. The literal meaning of the word Sanscrita is *polished*, and it is used by grammarians in the sense of 'regularly inflected or formed.' (Colebrooke's *Remains*, vol. ii. p. 2.) It constitutes the most ancient literature of the Hindus, and is radically connected with the various dialects of Hindustan, so that they may be regarded as more or less deflected from it. In the Hindu drama, the gods and saints are made to speak in Sanscrit; while women, benevolent genii, &c., speak another dialect, and the lower personages a third. (H. H. Wilson, *Hindoo Theatre*, Introduction.) The attention of European enquirers was directed to the Sanscrit and its cognate language by Sir William Jones. Since his time the study has made great progress in England, where it has been especially furthered by the labours of Houghton, Wilkins, and Wilson; and more in Germany, where Frederic Schlegel (*Sprache, &c. der Indier*, 1808) was the first to excite the spirit of investigation. He was followed by his brother, A. W. Schlegel (who edited the *Bhagavat Gita*, translated into English by Mr. Wilkins) and many others. Among more recent German philologists, Bopp deserves the highest name for his researches in this direction. For the history of the language, and its relation to the other languages of the Aryan family, see Max Müller's *Lectures on the Science of Language*, p. 139, &c. [LANGUAGE; PRAKRIT.]

Sanseviera (after Sansevier, a Swedish botanist). A tropical genus of Liliaceous plants, remarkable for the toughness of the fibre embedded in their fleshy leaves, whence the plants obtain the name of Bowstring Hemps, the fibres of their leaves being used for bowstrings by the natives of the countries where they are indigenous. The genus is very closely allied to *Dracæna*. *S. guineensis* is the African Bowstring Hemp; *S. Roxburghiana* is the Moorva or Marool of the Indian peninsula. The fibre of the Moorva is very strong and of fine quality, and is suitable for the manufacture of fine string and cordage.

Santalaceæ (Santalum, one of the genera). A natural order of Epigynous Exogens, of the Asaral alliance, distinguished by the one-celled ovary, and the definite ovules having a coated nucleus. The species are sometimes herbs, sometimes shrubs and trees, and often grow parasitically on the roots of other plants. The typical genus is *Santalum*, which yields SANDAL WOOD.

Santalin. The colouring principle of red Sandal or Saunders wood, from which it is separated by digesting the rasped wood in alcohol, and then, on adding water to the tincture, it falls in the form of a bright red precipitate, soluble in alcohol and in alkaline solutions. A colourless crystalline substance has been separated from red sandal wood, and is described by Preisser under the name of *Santoline*, which by oxidisement and by the action of several chemical reagents acquires a red colour and is converted into what he terms *Santoléine*. But the existence of these colourless bases or sources of the above and other colouring matters requires further confirmation.

Santonin. A proximate vegetable principle, obtained from the flower-heads of *Artemisia santonica* and other species, known in pharmacy as *wormseed*. It is white, crystallisable, bitterish, and very little soluble in water, but more so in alcohol. It is occasionally used as a vermifuge in doses of from 10 to 30 grains, followed by a brisk purge. The so-called *wormseed* of the druggists, kept in the shops under the name of *semen cinæ*, and *semen contra* appears to be derived from several species of *Artemisia* and to be a mixture of broken peduncles, calyces, and flower-buds. The formula $C_{10}H_6O_2$ has been assigned to Santonin.

Saouari or Souari Wood. A valuable ship-building timber obtained from *Caryocar nuciferum* and *tomentosum*, trees which also yield the delicious souari nuts.

Sap (Fr. saper, Ital. zappare). In the attack of a fortress, the excavation of a trench under the

musketry fire of the besieged. When a sapper carries two gabions, and excavates the earth behind them, it is called a *flying sap*. When a squad of sappers works behind a *sap roller*, it is called a *single sap*. When the approach cannot be made by zigzags, and two single saps are carried on side by side directly towards the front, with a parapet on the outer side of each, it is called a *double sap*.

Sap (Lat. sapa, Gr. ὀπός). The fluid absorbed from the earth by the roots of plants, then sent upwards into the stem, and afterwards conveyed from the leaves, where it is assimilated and altered, to the bark. In its crude state it consists of little except water holding earthy and gaseous matter in solution, especially carbonic acid; but as it rises through the tissue of the stem it dissolves the secretions which it meets with in its course, and thus acquires new properties, so that by the time it reaches the leaves it is entirely different from its state when it first enters the root. The course taken by the sap in its passage through the stem is by the whole of the tissue included within the bark, provided it is all permeable; but as, in many plants, the central part of the stem becomes choked up with solid matter deposited in the tissue, it usually happens, especially in trees, that the course of the sap is confined to the outer part of the wood, hence called Sapwood. It is not certainly known through what kind of tissue the upward motion of the sap takes place, but it is probable that it is carried onwards through all the tubes and vessels of the wood and their intercellular passages. The dotted vessels of the wood seem more especially destined to fulfil this office when the sap is in rapid motion; but as they afterwards become empty, while the ascent of the sap continues, there can be no doubt that the woody tubes or pleurenchyma offer the most constant means by which the sap is conveyed.

Sap Ball. A local name for those *Polypori* which grow on trees, but applied more especially to *P. squamosus*, the stem of which when large, after the juice has been squeezed out, is sometimes used by boys as the foundation for tennis-balls. The same species is sometimes used, when properly dried and shaped, to form razor-strops.

Sap Fork. An instrument like a boat hook, used to push on a sap roller in sapping. [Sap.]

Sap Green. The inspissated juice of the berries of the buckthorn (*Rhamnus catharticus*). It is used by water-colour painters as a green pigment. It is the *vert de vessie* of the French. A colouring matter extracted from the excrement of the silkworm is also termed sap green.

Sap Roller. A large gabion, six feet long, and four in diameter, rendered bullet-proof by fixing another gabion six feet long by two and a half in diameter inside it, and filling up the space between with stout wooden pickets. [Sap.]

Sapan Wood. A dye wood produced by certain species of *Cæsalpina*—*C. Sappan*, *coriaria*, &c. It has long been used in India, and resembles Brazil-wood in its colour and properties.

Saphena (Gr. σαφής, *distinct*). The large vein of the leg which ascends over the external ankle.

Sapindaceæ (Sapindus, one of the genera). A natural order of Thalamifloral Exogens, consisting of exotic trees and shrubs, the larger part of which occur in South America. They usually have compound leaves and inconspicuous flowers, resembling those of European maples; and many of them are climbing plants. The order is poisonous in various degrees; nevertheless, the arillus of *Blighia sapida* is an esteemed fruit in Africa and the West Indies, where it is called the *Akee*. The most singular property observed in the order is that of having an astringent quality, and forming a lather when agitated in water, whence the name of the typical genus—from sapo, *soap*.

Sapodilla. The name of the *Sapota Achras*. Its timber, called Sapodilla Wood, is a fancy West Indian furniture wood.

Saponification (Lat. sapo, saponis, *soap*, and facio, *I make*). The formation of soap. It consists in the decomposition of fats, which consist of acids and glycerin, by alkalies which are chemically stronger than glycerin, and therefore displace it. Mere ebullition of the alkaline solution with the fat is usually sufficient to effect saponification. On adding salt to the resulting liquid, the soap is precipitated.

Saponin (Lat. sapo). A peculiar substance contained in the root of the *Saponaria officinalis*, and the fruit of *Sapindus Saponaria* and other species. It is the cause of the lather which the root and seeds of these plants form with water. A similar principle is found in Senega, Pimpernel, the Horse-chestnut, and in several varieties of *Lychnis*. An infusion of soapwort is sometimes used instead of soap for cleansing the finer varieties of wool.

Saponite. [Soapstone.]

Sapotaceæ (Sapota, one of the genera). A small natural order of Thalamifloral Exogenous trees inhabiting the West Indies and other tropical countries. In some cases they produce eatable fruits, known by the colonial names of Sapodilla, Marmalade Apple, Star Apple, Surinam Medlar, &c. The juice is white like milk; and, unlike the secretions of most lactescent families of plants, may be used for alimentary purposes. The fruit of some yields a greasy substance; whence one of them, *Bassia*, has gained the name of *Shea*, or Butter-tree, in Africa.

Sappare. A name which was given to Kyanite, by De Saussure, owing to a mistake in reading a label on which it had been incorrectly called Sapphire. Transparent blue Kyanite is sometimes polished and substituted for Sapphire, but is easily distinguished by its very inferior hardness.

Sappers and Miners. The name given to the non-commissioned officers and privates of the corps of Royal Engineers. Their duties

consist in building fortifications, in executing field works, &c., under the direction of their superior officers. [ENGINEERS, ROYAL.]

Sapphic. The name given to a species of verse; from Sappho, the famous Greek poetess, by whom it was said to be invented. It consists of eleven syllables of five feet, of which the following is a plan:—

–⏑ | –– | –⏑⏑ | –⏑ | –⏑ |.

This measure was afterwards introduced into Latin, and received great improvements in the hands of Horace and Catullus. The rules for the composition of Greek are much less strict than those for the composition of Latin sapphics. The sapphic strophe consists of three sapphic verses, followed by a *versus Adonicus*, or Adonian verse. [ADONIC.]

Sapphire (Gr. σάπφειρος). The name given to brightly coloured varieties of Corundum. The *blue* are generally called Sapphire; the *red*, Oriental Ruby. Sapphire consists essentially of crystallised alumina and is inferior in hardness only to the diamond. It occurs in variously terminated six-sided prisms and in rolled masses; and is found in the beds of rivers and associated with crystalline rocks, chiefly in Ceylon and Pegu; but it is also met with in Bohemia; near Expailly, in Auvergne; and in New South Wales. Sapphires have been used not only as ornamental stones but for the lenses of microscopes, for jewelling watches, and, when bored, for drawing very fine gold and silver wire. [CORUNDUM; STAR-STONE.]

Saprophagans (Gr. σαπρός, *putrid*, and φαγεῖν, *to eat*). The name of a tribe of Coleopterous insects, comprising those which feed on animal and vegetable substances in a state of decomposition.

Sapucaia Nuts. The seeds of *Lecythis Zabucajo*, imported from Pará, and commonly sold in the fruit shops. They somewhat resemble Brazil nuts, but are superior in flavour and more digestible.

Sapwood. The external part of the wood of Exogens, which, from being the latest formed, is not filled up with solid matter, or with the colouring principles which are deposited in wood after a certain time. For these reasons, sapwood is that through which the ascending fluids of plants move most freely; and not being solidified by the earthy and other substances eventually incorporated with wood, is quickly decomposed when exposed to the action of air and moisture. Hence for all building purposes the sapwood is, or ought to be, removed from timber. The sapwood or unsolidified wood of all trees is much the same in its power of resisting decomposition, that of the oak and lignum vitæ perishing as quickly as poplar and other valueless timber; and chemists have ascertained that if the hardest heartwood is reduced to its original condition of sapwood by the abstraction of the matter of solidification, all those properties which give heartwood its value are destroyed.

Sarabaites. Oriental monks or cœnobites, described by Cassian in his *Institutions*; and supposed to be the same with those called Remoboth by St. Jerome (*Epist.* xviii.).

Saraband (Span. zarabanda, Ital. sarabanda). In Music, a composition in triple time very similar to a minuet. When denoting music for the dance, it is to the same measure which usually terminates when the beating hand rises; being thus distinguished from the *courant*, which ends when the hand falls.

Saracenic Art. A style allied to the Byzantine, being developed by Byzantine Greeks for the Arabs. The details are composed of conventional flowers and tracery, with ingenious variations of the early Christian symbolism disguised. Its great feature is the exclusion of all imitation of nature. (Owen Jones's *Alhambra*; Wornum's *Analysis of Ornament, &c.*) [DECORATION; ORNAMENT.]

Saranyû. [ERINYS.]

Sarcocarp (Gr. σάρξ, *flesh*, and καρπός, *fruit*). In Botany, the fleshy part of a pericarp, lying between the epicarp and endocarp.

Sarcocele (Gr. σαρκοκήλη, from σάρξ, and κήλη, *a tumour*). A tumefaction of the testicle.

Sarcocol (Gr. σαρκοκόλλα, *a Persian gum*). A gum resin, said to be the produce of *Pœnea Sarcocolla*, a plant growing in the northern parts of Africa. This Sarcocol somewhat resembles gum arabic; but is soluble in alcohol, and its aqueous solution is precipitated by tannin.

Sarcocollin. A gummy matter contained in commercial *sarcocolla*, the dried juice of the *Pœnea mucronata*.

Sarcode (Gr. σαρκώδης, *flesh-like*). The organised substance of which the soft parts of Protozoa (Sponges, Infusories, Foraminifers) are composed.

Sarcoderm (Gr. σάρξ, and δέρμα, *skin*). In Botany, an intermediate fleshy layer found in the testa of some seeds.

Sarcolite (Gr. σάρξ, and λίθος, *stone*). A pale, flesh-coloured Zeolite, found in small semi-transparent crystals at Monte Somma; with Wollastonite, Hornblende, &c. It is a silicate of alumina, lime, and soda.

Sarcology (Gr. σάρξ, and λόγος, *a discourse*). The history or doctrine of the fleshy parts of the body.

Sarcophagus (Gr. σαρκοφάγος, from σάρξ, and φαγεῖν, *to eat*). In Antiquities, a stone receptacle for a dead body. The name originates in the use of the lapis Assius, stone of Assos (in Asia Minor), said to have been prepared for this purpose, on account of its supposed property of corroding dead bodies, so as to consume them entirely in forty days; which, together with other incredible qualities, is ascribed to it by Theophrastus and Pliny. One of the most celebrated specimens of this object of art is the great sarcophagus taken by the British in Egypt in 1801, commonly called that of Alexander: it is deposited in the British Museum. Dr. Clarke, the traveller, wrote an essay to prove that the Macedonian conqueror

had really been entombed in it; but this opinion seems unfounded.

Sarcosine (Gr. σάρξ). A basic substance obtained by boiling kreatin with hydrate of baryta. Its formula is $C_6 H_7 O_4 N$.

Sardines. Small fishes of the Herring family (*Clupea sardina*, Cuv.), taken in vast numbers off the coast of Sardinia, and in other parts of the Mediterranean, where the herring is unknown. They form an important article of commerce, their flavour being highly esteemed.

Sardonic Laugh. [Risus Sardonicus.]

Sardonyx (Gr. σαρδόνυξ). Onyx consisting of alternate layers of Sard and nearly opaque-white Chalcedony. It is the most beautiful and the rarest variety of Onyx, and that which was held in the greatest esteem by the ancients for engraving into cameos. The Sardonyx is found in Perthshire.

Sargassum (Span. sargazo, *sea-weed*). The scientific name of the Gulf-weed, which forms a genus of dark-spored *Algæ* belonging to the natural order *Fucaceæ*, and is characterised by the fruit-bearing receptacles being collected in little bundles in the axils of the leaves; the air-vessels, which are merely transformed leaves, with or without a terminal point, being stalked and separate. The species are extremely numerous, and chiefly tropical or subtropical. We have no species inhabiting our shores, but *S. vulgare* and *S. bacciferum* are occasionally transported to us by the waves. Its abundance over a large portion of the Atlantic has led to the Portuguese expression *mar de Sargasso*, or weedy sea.

Saros. An ancient Assyrian astronomical period, the origin and exact length of which are unknown, though they have been the subject of much disputation. Georgius Syncellus, who wrote in the eighth century, cites a passage from Berosus, reported by Julius Africanus, in which mention is made of three periods—the *Sosos*, the *Neros*, and *Saros*; and the Saros is stated to be 3,600 years. According to Lalande (*Astronomie*, § 1,572), Syncellus also cites Anianus and Panodorus, who assigned the lengths of these periods as follows: The Sossos, 60 days; the Neros, 600 days; and the Saros, 3,600 days, or 9 common years 10 months and 11 days. Legentil, after Fugeres, supposes the Saros to be 10 years; Freret supposed it to be 19½ years; Giraud, 3,600 Julian months, which make 3,711 lunations, or 31 years. Suidas states that the Saros was a period of lunar months equal to 18½ years; and Halley (*Phil. Trans.* No. 194), adopting the same notion, and supporting himself by a passage in Pliny, supposes it to be identical with the lunar period of 18 years, or rather of 223 lunations, which corresponds almost exactly to 242 *nodical* revolutions of the moon [Moon], and consequently brings back the eclipses in the same order. But Goguet (*Origine des Loix*, *&c.*) remarks, that the statement of Suidas is not supported by that of any ancient author; and that there is no reason to suppose that Pliny, in the passage in question, had the Saros in view. By some authors the Saros has been confounded with the *Metonic cycle*. (Sir G. C. Lewis, *Astronomy of the Ancients*, p. 401.)

Sarothamnus (Gr. σάρος, *a broom*, and θάμνος, *a shrub*). A genus of *Leguminosæ*, comprising the common Broom, which bears the name of *Sarothamnus scoparius*, though perhaps better known under those of *Spartium* or *Genista*. The Broom grows naturally in the Canary Isles, Western Europe, and Scandinavia, as well as in Britain, and is applied to various economic purposes. Neat little baskets are made from the twigs divested of their bark in Madeira; and in some parts of Europe the green tops are used as winter food for sheep.

Broom-tops in large doses are emetic and purgative, in small doses diuretic and laxative.

The *Ordre de la Geneste*, or Order of the Broom, was the denomination of an order of knighthood instituted by Louis of France in 1234, and continued till the death of Charles V. The Broom was not less distinguished than the Rose herself during the civil wars of the fourteenth century; for a sprig of the *Planta Genista* was the adopted badge of Geoffrey duke of Anjou, father of Henry II. [Plantagenet.]

Sarpêdon (Gr. Σαρπηδών). There were three persons of this name in Greek mythology, the first being a son of Zeus and Europa, and brother of Minos and Rhadamanthus. He became king of the Lycians [Lycaon; Rishis], and received from Zeus the gift of a life equal in length to three generations. The hero in the Homeric tale of the Trojan war is a grandson of this Sarpedon. With his friend Glaucus (another form of λευκός, *the brilliant*) he goes from his bright, or Lycian, land, to aid Hector at Ilion, where he is slain by Patroclos, Zeus being unable to avert his early doom, although his tears fell in rain-drops from the sky. At the bidding of Zeus, Apollo bathed his body and wrapped it in an ambrosian garment, and Sleep and Death (Thanatos and Hypnos) bore it in the still hours of the night to his home in Lycia, where a great cairn marked his burial-place.

The root of the name (sar, *to go*, Lat. serpo) reappears in the names Hermes and Helen.

The incident which is said to have won for Sarpedon the chieftainship over the Lycians is repeated in the legend of William Tell.

Sarraceniaceæ (Sarracenia, one of the genera). A small group of curious herbaceous Exogens, inhabiting the bogs of North America, and having their leaves hollowed out into tubes or pitchers open at the upper end. Their flowers have some likeness to those of *Papaveraceæ*, to which order they are allied.

Sarsaparilla. The rhizome of various species of *Smilax*. Several varieties of this drug are imported from South America. That which is generally preferred is the reddish fibrous root, known in the market under the

name of *Jamaica* or red sarsaparilla, and referred to *S. officinalis*. What is termed *Lisbon* sarsaparilla, referred to *S. papyracea*, is less fibrous, and more mealy and white in the interior.

This root, though long employed in medicine, seems only lately to have been properly estimated. It was formerly regarded as a specific in syphilis; but this opinion is now given up, and it is used as a powerful and valuable alterative medicine in many disorders of debility, but more especially in those cachectic habits which present symptoms formerly mistaken for venereal—such as pains of the bones, nodes of the periosteum, loss of strength and flesh, and other characters of what is sometimes called a broken constitution. In these cases a course of sarsaparilla has often effected a cure, especially if resorted to in time, when all other remedies, and more especially mercurials, had failed. It must be taken in pretty large doses, i. e. in quantities not less than an ounce to an ounce and a half a day, and persevered in for six, eight, or ten weeks; or a quantity of extract or syrup, or other preparation equivalent to that weight of the dried root. A concentrated liquid extract, and a syrup, are now prepared, which are the best forms. They are apt to disagree with weak stomachs; but generally, by proper management and perseverance, this difficulty may be got over. Where it agrees, the strength is gradually regained, the pains and other symptoms abate and vanish; and the only other effect observed is, either that the bowels are rather more open than usual, or the flow of urine or the perspiration is increased.

Sartorius Muscle. A muscle of the thigh attached at the upper extremity to the edge of the anterior superior spinous process of the ilium, and at the lower to the inner side of the head of the tibia. It is concerned in bending the leg obliquely inwards, and in crossing the thighs; thence called sartorius, or the *tailor's muscle*.

Sash (Fr. chassis). In Architecture, a piece of framing for holding the squares of glass in a window. It is of two sorts—viz. that called the French sash, which is hung like a door to the sash frame; and that in which it moves vertically from being balanced by a weight on each side, to which it is attached by lines running over pulleys at the top of the sash-frame. When in a window both the upper and lower sashes are movable, the sashes are said to be double hung, and single hung when only one of them moves.

Sassafras. The *Laurus Sassafras*, now *Sassafras officinale*, a native of North America, and growing abundantly upon the banks of the river Sassafras; whence its name. It has a warm aromatic flavour, and the decoction is diuretic and diaphoretic. It was formerly used in cases of stone in the bladder (hence its name has by some been derived from saxum, *a stone*, and frangere, *to break*). It has also been extolled as an antisyphilitic remedy, and in rheumatic and cutaneous affections: but it is now scarcely ever employed except as an ingredient in the compound decoction of sarsaparilla.

In medicine various preparations of Sassafras are used in rheumatic and skin affections, generally, however, in combination with other more potent drugs. Sassafras-tea mixed with milk and sugar forms the drink known as Saloop, which is still sold to the working-classes in the early morning at the corners of the London streets. In Virginia the young shoots are made into a kind of beer; in Louisiana the leaves are used as a condiment in sauces, while their mucilaginous properties render them useful for thickening soups.

What is known as Orinoco Sassafras is the produce of *Nectandra cymbarum*, while Cayenne Sassafras is derived from *Licaria guianensis*.

Sassolin. Native boracic acid, from the vicinity of Sasso in Florence.

Satan. A Hebrew word signifying *enemy* or *adversary*; and used as such, without any reference to the Evil Power itself, in one or two passages of the Old and New Testament. The equivalent term in Greek for this word is διάβολος, literally *one who accuses or calumniates*. [Devil; Vritra.]

Satellite (Lat. satelles, *an attendant*). In Astronomy, the name given to the secondary bodies revolving round planets, though to speak more generally the planets themselves are satellites of the sun and each member of a double or multiple star-system comes under the same category.

The planets which are accompanied by satellites are the Earth, Jupiter, Saturn, Uranus, and Neptune. The Earth has one satellite, namely, the Moon; Jupiter has four; Saturn eight; Uranus four; and Neptune probably two. For the Earth's satellite, see Moon.

The Satellites first discovered (leaving the Moon out of the question) were those of Jupiter, first observed by Galileo, and their discovery followed immediately that of the telescope. With a telescope of ordinary power they may be seen (unless when eclipsed by the shadow of the planet, or concealed behind its disc), on any clear night, at different distances from the planet, and arranged nearly in a straight line, in which they appear to oscillate backwards and forwards with different velocities, and performing unequal excursions; so that their arrangement with respect to the planet, or *configurations*, are constantly changing. Sometimes they are observed to pass before Jupiter, in which case they cast a shadow on his disc like a small round black spot, whence they are inferred to be opaque bodies illuminated by the sun; at other times they pass behind the planet, and are concealed from our view; and all these phenomena occur in regular order, and, with respect to each satellite, after the same intervals of time.

From the table it will be seen that the periodic time of the first satellite of Jupiter

is nearly half that of the second, and that of the second nearly half that of the third. The mean angular motions of these three satellites, therefore, form very nearly the progression 1, ½, ¼; so that the mean motion of the first satellite, added to twice that of the third, is very nearly equal to three times the mean motion of the second. Another equally singular analogy is, that the mean longitude of the first, *minus* three times that of the second, *plus* twice that of the third, is always very nearly equal to two right angles. These two results subsist equally in respect both of the sidereal and synodical motions and longitudes; and it follows as a consequence of the last, that for a great number of years at least, the three first satellites cannot be eclipsed at the same time, for in the simultaneous eclipses of the second and third the first will always be between the Sun and Jupiter, and vice versâ.

On account of the shortness of the periods of revolution, the eclipses of the satellites (especially of the first) take place very frequently; and they are phenomena of considerable importance in astronomy, from their affording signals by means of which the differences of terrestrial longitudes are determined, in the same manner as in an eclipse of the moon. The method, however, is not capable of the same precision as is afforded by lunar observations. [LONGITUDE.]

The eclipses of Jupiter's satellites have also an historical interest, from having led Rœmer to the important discovery of the successive propagation and velocity of light. When Jupiter is in opposition with the sun, and his distance from the earth consequently *less* than his distance from the sun by the whole radius of the earth's orbit, the eclipses are observed to happen about 16 m. 26 sec. earlier than when the planet is in conjunction, and its distance from the earth *greater* than its distance from the sun by the same quantity. This phenomenon can only be explained by supposing that light occupies 16 m. 26 sec. in traversing the earth's orbit, and consequently 8 m. 13 sec. in coming from the sun to the earth, which gives a velocity of about 192,000 miles in a second. The theory, with its consequences, has been amply confirmed by Bradley's discovery of aberration. [ABERRATION.]

The satellite in which we are chiefly interested is the moon, which will be found described in its proper place. Below we give, however, the elements of all the satellites of our system. It will be seen that the number of satellites apportioned to each planet is very unequal, Saturn having the largest number, and Venus, Mars, and Mercury being entirely deprived of them. There is reason for believing that some of the satellites both of Jupiter and Saturn possess the same peculiarity as our moon, namely, that their times of revolution and rotation are equal. The elements of the satellites are as follow (the article PLANET should also be consulted):—

Elements of the Satellites.

Primary	No.	Name	Distance from Centres of Primaries: In Radii of Primary	Distance from Centres of Primaries: Miles	Excentricity	Longitude of Peri-planetum	Inclination of Orbits to Plane of Ecliptic	Sidereal Revolution	Diameter	Max. Elongation	Mass	Apparent Star Magnitude
						° ′ ″	° ′ ″	d. h. m. s.	Miles	′ ″	Earth = 1	
Earth	1	Moon	60·273433	237613	0·054908	266 10 75	5 8 40·0	0 29 34 66	2160	. .	0·011364	
											♃ = 1	
Jupiter	1	Io	6·04853	278542	. .	. .	3 4 6	1 18 27 24	2440	2 15	0·000017	7
	2	Europa	9·62347	442904	. .	. .	3 5 5	3 13 13 42	2192	3 35	0·000023	7
	3	Ganymede	15·35024	706714	. .	. .	3 9 2	7 3 42 33	3579	5 46	0·000088	6
	4	Callisto	26·99835	1·242619	. .	. .	3 28 0	16 16 32 11	3062	9 45	0·000043	7
Saturn	1	Mimas	3·3607	119725	0·06889	104 42		0 22 37 28	?1000	0 33	. .	17
	2	Enceladus	4·3125	153630	?	?		1 8 53 7	?	0 43	. .	15
	3	Tethys	5·3396	190225	0·0051	184 36		1 21 18 26	?	0 53	. .	13
	4	Dione	6·8398	243670	0·02	42 30	23 10 22	2 17 41 9	?	1 8	. .	12
	5	Rhea	9·5528	340320	0·02269	95 00		4 12 25 11	1200	1 35	. .	10
	6	Titan	22·1450	788915	0·02922	244 35·5		15 22 41 25	3300	3 41	. .	8
	7	Hyperion	26·7834	954160	0·115	295 00		21 7 7 41	?	4 40	. .	17
	8	Japetus	64·3590	2·292790	0·025	130 00		79 7 54 40	1800	10 43	. .	9
Uranus*	1	Ariel	7·44	128340	. .	. .	100° 0′34	2 12 28 0	. .	0 12		
	2	Umbriel	10·37	178882	. .	. .	Ascending	4 8 27 0	. .	0 15		
	3	Titania	17·01	293422	. .	. .	Node	8 16 55 0	. .	0 33		
	4	Oberon	22·75	392507	. .	. .	165 30	13 11 6 0	. .	0 44		
Neptune†	1	. .	12·00	225000	0·1059748	177 30	29 ±	5 21 8 0	. .	0 18	. .	14

* The motion of the Satellites of Uranus is retrograde. † Motion possibly retrograde.

Additional Elements of the Moon.

Mean Horizontal Parallax	= 57′ 2″·70	Daily Geocentric Motion	13° 10′ 35′
Mean Angular Telescopic Semi-diameter	15′ 33″·36	Mean Revolution of Nodes	6793·39108d
Ascending Node of Orbit	13° 53′ 17″	„ „ Apogee or Apsides	3232·57343
Mean Synodic Period	29·530588715 days	Density, Earth as 1	= 0·56654
Time of Rotation	27·321661418 „	Volume, „	= 0·02012
Inclination of Axis to the Ecliptic	1° 30′ 10″·8	Force of Gravity at Surface, Earth as 1	= ⅙
Longitude of Pole	?	Bodies fall in One Second	2·6 feet

Satin (Fr.; Welsh sidan). A closely woven silk, generally dressed with gum, especially when intended for ribbons, dresses, &c.

Satin Spar. A fibrous variety of carbonate of lime, which when polished has a lustre resembling that of satin. It is found of snowy whiteness in Buckinghamshire, Cumberland, Devonshire, at Leadhills in Scotland, and elsewhere.

The mineral which is more commonly known by the name of Satin Spar is a much softer stone than the above, being a fibrous kind of Gypsum (a sulphate of lime) found in Nottinghamshire, Derbyshire, Gloucestershire and near Carrickfergus in Ireland. This variety is frequently made into beads and other ornaments, which have a certain kind of resemblance to Cat's-eye; but it is of a much softer nature.

Satin Wood. A handsome Indian wood obtained from *Chloroxylon Swietenia*, and valuable for veneering purposes.

Satire (Lat. satira). In Literature, a representation of vice, or of the ridiculous, either in the form of discourse or put in dramatic action. The word *satire* must not be confounded as to its etymology with the satyri of the Greeks, which were burlesque dramatic pieces, in which the persons represented a band of satyrs. [Drama.] The Latin satira is said to be derived from the *lanx satura*, a dish full of various fruits and herbs which was carried in procession at the feasts of Ceres. Hence the word came to signify a poem full of miscellaneous matter without orderly method, and in this sense only it was probably employed by Lucilius, the first writer of satires, although the title so usurped by him was afterwards applied only to poems of a similar character with his own, viz. containing moral reflection, interspersed with critical touches directed against real or imaginary personages.

Satire, in the literary sense of the word, as designating a species of composition, is usually confined to a species of poetry; but prose works, of which the contents are of a satirical character, are often comprehended under the same appellation. Dramatic writings, also, are not satires in the stricter sense of the word, although their contents may be of a satirical character. According to their subjects, satires are divided into political and moral; and these again severally subdivided into personal and general. Political satires, in almost every language, have been nearly confined to prose; the moral satire alone has found its appropriate vehicle in verse. The only Greek satirist, of whom any fragments have reached us, was Archilochus; and his attacks were evidently directed against individuals. Aristophanes possessed a vein of satirical power, both in the indignant and ludicrous strain, which has never been surpassed; and his dramas contain not only sarcasms on individuals, but also political and ethical lessons of the highest value. But the moral satire, properly so called, was invented by the Romans, not only in form, but in substance, and by them carried to perfection; and it is remarkable that the only species of Roman poetry which has any degree of originality, is that which would seem to have accorded the least with the grave and austere turn of the genuine Roman character.

Of the three Roman satirists whose works have reached us, Horace, the earliest, excels in conveying moral and prudential lessons, in light allusions to the follies or excesses of his time; sometimes, though rarely, assuming the comic character, but generally evincing more of the indefinable quality termed by us humour, than is shown by any other classical writer, with the exception of Aristophanes. Whether the various personages introduced by Horace, for the most part rather as examples to be shunned than as individuals to be held up to laughter or contempt, were intended to represent to his readers, by allusions now undiscernible, actual characters known to them, is a matter not easily ascertainable. The same may be said with respect to Juvenal, whose selected victims are for the most part exalted or notorious personages of the generations immediately preceding his own; and it is not ascertained, although it has often been conjectured, that their names were intended to conceal those of his contemporaries. Juvenal, without either wit or humour, excels in the deep tones of moral indignation befitting the scandalous excesses of the times in which he lived. Persius, although he occasionally rises into very elevated flights of poetry, does not afford many examples of the peculiar excellences of the satirist.

In the literature of modern nations, the fate of satire has been similar to that which has befallen many other species of composition. The name and form of the ancient satire have been preserved by many writers, who have produced, for the most part, little besides cold or exaggerated imitations of antiquity. But the true spirit of satire, in its moral beauty, its humour, and its delicate irony, has been inherited by authors in other classes of literature, who had too much originality of thought to tie down their genius to an antiquated form of writing. Thus in France, Boileau is or was generally cited as the prince of satirists: his satires are closely formed on the model of Horace, and are elegant and correct in style. Besides him, Régnier and many other writers have adopted the same line. But the true satirists of France are Rabelais, in his inimitable romances; Montaigne the essayist, endowed with much of the delicate sarcasm of Horace; and, in later times, Voltaire. So in England, although we possess satirists of considerable merit, who have adopted the form of the ancient satire, our true national satirists are to be found among our essayists and novel-writers. Bishop Hall, in the reign of Elizabeth, and Donne, in that of James, published collections of satires, directed partly against the actual follies or vices of their times, but too closely paraphrased, for

the most part, from the Latin, to admit of much original observation. Withers, among our early satirists, is the only other writer who is at all remembered. Among our modern poets, Pope founded his satires chiefly on the model of those of Horace; but his style and train of thought were rather French than Roman. His works of this class are, in point of form, mere imitations; but they are admirable for their point and the beauty of the verse, and not unfrequently contain pungent personal allusions, without which, unfortunately, a professed satirist can attract little notice and produce little effect. Johnson (in his two well-known imitations of Juvenal), Churchill, and Young, are the latest writers of any note who have composed in the form of the ancient satire. But of all these writers, not one possesses a genuine or national character, except perhaps Churchill; while Swift, Fielding, Dickens, Thackeray, &c., are, in our literature, what Horace and Juvenal were in those of the Romans—although not technically satirists, yet the painters of existing manners, and the representatives of public opinion respecting them. The literary satire, may, perhaps, be mentioned as a separate species of composition, containing either rules of writing, or critical observations on the defects of individual writers. Some of Horace's satires and epistles (as well as his *Ars Poetica*) belong exclusively, others partially, to this class; and have given birth to a series of similar productions, down to the *English Bards and Scotch Reviewers* of Lord Byron.

Satisfaction (Lat. satisfactio). In Law, satisfaction of legacies, portions, and debts, means the donation of a thing with the intention, either expressed or implied, that it is to be taken in whole or part extinguishment of some prior demand. Thus the advancement of a portion by a parent to a child is in certain cases the satisfaction (either wholly or partially) of a legacy, and vice versâ, the presumption being that the child was not intended to have a double provision. And this doctrine has in many cases been extended to gifts of sums of moderate amount which the donors very probably did not really intend should be received as part of the child's ultimate fortune. Again, if a debtor bequeath to his creditor a sum of money equal to or greater than the amount of the debt, this will be considered to have been intended as a satisfaction of the debt.

Satisfied Terms. In Law. In the practice of Conveyancing it is common to limit long terms of years to trustees upon trusts for raising money out of an estate, &c. When these trusts are fulfilled the term is said to be *satisfied*, and it was formerly usual upon subsequent dealings with the property to convey the unexpired residue of such terms upon trust (as it was said) to attend the inheritance, as there were cases in which terms so assigned might be used as a protection by purchasers, mortgagees, &c., against incumbrances of which they had no notice. The statute 8 & 9 Vict. c. 112 put an end to satisfied terms, and consequently to the practice of assigning them.

Satrap (Gr. σατράπης, Lat. satrapa, identified by Michaëlis with the Persian Schahderbân, *the king's door-keeper*). The title given by the Greek writers to the governors of provinces under the Persian kings before the conquests of Alexander. The satrapies of the Persian empire are enumerated by Herodotus, iii. 89. (*Mém. de l'Acad. des Inscr.* vol. xxxi.)

Saturation (Lat. satur, *full*). In Chemistry, a fluid is said to be saturated with a substance when it holds as much of it in solution as it can take up and retain: we thus speak of *saturated solutions* of saline, and other bodies. The term *saturation* is also especially applied to the combination of acids and alkaline or other basic bodies, in such definite proportions as neutralise each other; thus we say that sulphuric acid is saturated by potassa, when neither acid nor alkaline properties are predominant: hence, also, the resulting sulphate of potassa is called a *neutral salt*. An excess of acid would be termed *supersaturation*.

Saturation, Fraction of. The term *fraction of saturation* is used to denote the ratio of the elastic force of the vapour actually existing in the atmosphere, to the elastic force of as much vapour as atmospheric air is capable of containing in an equal volume and at the same temperature, or as would *saturate* the air.

Saturday. The seventh day of the week, held by the Jews as their sabbath. It receives its name from the god Sæter, or Saturn. [SUNDAY.]

Satureja (Arab. Statter, a name for labiate plants). A genus of *Labiatæ* yielding the herb known as Savory, of which two sorts, the summer and the winter, are cultivated, both highly esteemed in cookery for their powerful aromatic flavour. Both species were noticed by Virgil as being among the most fragrant herbs, and on this account were recommended to be grown near beehives. Vinegar flavoured with savory and other aromatic herbs was as much used by the ancient Romans as mint-sauce is at the present day with us. To preserve a supply, it should be cut just before the flowers expand, and dried by exposure to air.

Saturn (Lat. Saturnus). In Astronomy, one of the principal planets in the solar system, and the sixth in the order of distance from the sun. Though less brilliant than Venus and Jupiter, Saturn is nevertheless a conspicuous object in the heavens, and has accordingly attracted the attention of astronomers since the first dawn of the science.

The system of rings with which this planet is surrounded renders it a unique member of the planetary family; and modern investigations tend somewhat to show that we have in it an evidence of the truth of Laplace's hypothesis of the original formation of our system.

This singularity of Saturn's appearance was first noticed by Galileo, to whom the planet

appeared *triple*, or like a large body placed between two small ones. The explanation of the phenomenon was first given by Huygens. In addition to the apparently double ring revealed by the first telescopes, in 1850 a third ring, interior to the two others, was simultaneously discovered in America and this country. The new ring is very faint and dusky; and hence is called the *crape ring*; through it the body of the planet is easily visible. Modern observations have shown not only that this ring is double, but that the two rings first noticed are themselves subdivided into other rings, and that the number and position of the divisions are constantly changing.

When seen through a good telescope, the disc of Saturn appears striped with dark belts, somewhat similar to, but broader, less numerous, and less strongly marked than, those of Jupiter. From their parallelism to the planet's equator, it is inferred that they are probably determined by currents similar to our trade winds.

Saturn is attended by eight satellites; the two nearest the planet and Hyperion can be seen only under the most favourable circumstances, and with telescopes of very high power. [SATELLITE.]

From the circumstances of its casting a dark shadow on Saturn on the side nearest the sun, and receiving the shadow of the planet on the opposite side, it was at first inferred that Saturn's ring is composed of solid ponderous materials. But it also followed that the ring must therefore be under the influence of the planet's attraction, and so was liable to be deranged by the disturbing action of the satellites, the largest of which does not move in the same plane. Hence it became an interesting problem in physical astronomy to determine the conditions under which its equilibrium could be maintained. Laplace showed from the theory of gravitation, that in order to maintain the stability of the ring, it was necessary that the planet's attraction should be counteracted by a centrifugal force arising from a very rapid rotation of the ring in its own plane. Observation has confirmed the result of theory; for from the motions of certain dusky spots on its surface it has been found that the ring revolves in 10 h. 29 m. 17 s., which is very nearly the period assigned by Laplace, and that in which a satellite would revolve at a distance equal to that of the middle of the ring. Laplace also showed that in order to resist the tendency to subversion of the equilibrium, it was necessary to suppose the ring to be of unequal density or thickness in its different parts, so that the centre of gravity might not coincide with the centre of figure; for if it were perfectly similar throughout, its equilibrium would be disturbed by the slightest force, as the attraction of a satellite; and as it would have no tendency to recover itself, it would ultimately be precipitated on the planet. This inequality of form also would seem to be indicated by observation, for it has been noticed that the two arms of the ring sometimes appear to be of unequal length.

Since the time of Laplace this interesting problem has engaged the attention of some of the most powerful analysts. Pierce and Maxwell have by turns shown that the rings cannot be solid and cannot be liquid, and observation certainly endorses these theoretical results, the variations in the divisions of the rings, the, so to speak, birth of the crape ring, and the alleged increase in the breadth of the ring system, are irreconcilable with the assumption of solidity. It has therefore been suggested that the rings may be composed of an innumerable multitude of *satellites*. Mr. Proctor, in a remarkable book recently published (*Saturn and his System*) remarks as follows:—

'The temporary divisions and mottled stripes are easily explained. It is conceivable, for instance, that the streams of satellites forming the rings might be temporarily separated along arcs of greater or less length by narrow strips altogether clear of satellites, or in which satellites might be but sparsely distributed. Divisions of the former kind would appear as dark lines, while those of the latter kind would present precisely that mottled appearance seen in the dusky or ash-coloured stripes. The transparency of the dark inner ring is easily understood if we consider the satellites to be sparsely scattered throughout that formation. The fact that this ring has only become visible of late years no longer presents an insuperable difficulty, for it is readily conceivable that the satellites forming the dark ring have originally belonged to the inner bright ring, whence collisions or disturbing attractions have but lately propelled or drawn them. The gradual spreading out of the rings is explicable when the system is supposed to consist of satellites connected only by their mutual attractions; while the thinness of the system is obviously a necessary consequence of such a formation, for the attraction of Saturn's bulging equatorial regions would compel each satellite to travel near the plane of Saturn's equator.'

The elliptical shading noticed at the ends of the apparent longer axis of the dark ring, is also explained:—

'We have only to imagine that the satellites are strewn more densely near the outer edges of the bright rings, and especially of the inner bright ring, and that this density of distribution gradually diminishes inwards. For instance, we may conclude that along the inner edge of the inner bright ring the satellites are so sparsely strewn that, at the extremities of the apparent longer axis of that edge, *the dark background of the sky becomes visible through the gaps between the satellites*.'

Further particulars of this interesting system will be found noticed under PLANET and SATELLITES. We append in this place the latest values of the dimensions of the ring system, calculated according to both the old and new solar parallax. They are taken from Mr. Proctor's book already referred to.

Longitude of ascending node of ring on the ecliptic	167°	43′	28″·93
Inclination of rings' plane to the ecliptic	28	10	21·95
Annual precession of the vernal equinox of Saturn's northern hemisphere			3·145

Complete revolution of either equinox in 412,080 years

	Miles. Old Value.	Miles. New Value.
Exterior diameter of outer ring	173,500	166,920
Interior " "	153,500	147,670
Exterior diameter of inner ring	150,000	144,810
Interior " "	113,400	109,100
Interior diameter of the dark ring	95,400	91,780
Breadth of outer bright ring	10,000	9,625
" of the division between the rings	1,750	1,680
" of inner bright ring	18,300	17,605
" of the dark ring	9,000	8,660
" of the system of bright rings	30,050	28,910
" of the entire system of rings	39,050	37,570
Space between the planet and dark ring	10,150	9,760

As the plane of the rings is inclined to the ecliptic, and maintains its parallelism during the revolution of the planet, the angle under which it is presented to the sun is continually changing; the appearances which it presents to the earth are therefore also continually changing. The points in which it intersects the ecliptic are in 170° and 350° of longitude; consequently, whenever the planet comes into either of those longitudes (and it must pass through both in each revolution), the plane of the ring passes through the sun, and only the thin edge is illuminated. In this case, the whole quantity of light which is reflected from it is insufficient to render it visible, and it entirely disappears, even in the most powerful telescopes. On the 29th April, 1833, Sir John Herschel records, 'The disappearance of the rings is complete, when observed with a reflector 18 inches in aperture and 20 feet in focal length.' A little before or after the planet is in this position, the ring is seen as a fine straight line of light drawn across the disc of the planet, and projecting on each side. As the planet continues to recede from these points the sun's rays fall upon the ring, and the luminous line gradually opens out into an ellipse, which becomes wider and wider, until it attains its maximum when the longitude of Saturn is 80° or 260°. Now it is evident that the ring will be visible only when the sun and earth are both on the same side of it; and that it will become invisible when its plane passes through the centre of the earth as well as when it passes through the centre of the sun, though for a different reason. On this account two or three disappearances of the ring may happen in a short period of time. The disappearances take place about every 15 years, or half the time of Saturn's revolution in his orbit, and the two sides of the ring have alternately fifteen of our years of sunshine, and fifteen years of darkness.

SATURN. In Latin Mythology, a king of Italy, to whom was ascribed the introduction of agriculture. Saturn thus answers to TRIPTOLEMUS in the Greek legend of Dêmêtêr; and there can be little doubt that the name is connected with the Latin verb sero, satum, *to sow*, while nothing in his attributes corresponds to the Greek Cronos [ZEUS], with whom he has been generally identified. The wife of Saturn, the corngrower, was Ops (*wealth* or *plenty*). Like ROMULUS, Saturn disappeared from the earth when his work was done; and the fancies of mythographers derived the name of the Latin country, Latium, from this disappearance (lateo, *I lie hid*).

Saturnalia. In Roman Antiquities, the festival of Saturn, celebrated about the middle of December, and lasting at different times for one, three, and five days. It was a season of complete liberty and rejoicing. No business was done: friends visited and made presents to each other; and slaves were permitted to jest with their masters, and were waited on by them at table.

Satyr. In Zoology, the orang-utan (*Simia satyrus*, Linn.) is sometimes so called.

Satyrs (Gr. σάτυρος, another form of τίτυρος, *a ram*). In Mythology, beings represented with the heads, arms, and bodies of men, and the lower parts of goats. They were under the peculiar government of Dionysus or Bacchus.

Satyric Drama. In the Greek theatre, a theatrical piece, in which the chorus consisted of satyrs of a semi-burlesque character, as in the *Cyclops* of Euripides. It was customary for the tragedian to present at the same time three tragic pieces and one satirical drama, forming a tetralogy. (Smith's *Dictionary of Greek and Roman Antiquities*, art. 'Tragœdia.')

Saucer of a Capstan. An iron bed or socket bolted to the deck below that on which the capstan is, for the purpose of securing the pivot or spindle on which the apparatus works.

Saucisson (Fr.). [POWDER HOSE.]

Sauer or Sour Kraut. A salted preparation of cabbage much esteemed in Germany, and of which large quantities are prepared for winter use. It is made by shredding the cabbages and packing them in layers in barrels with salt, unground pepper, and a few cloves, the whole mass being firmly pressed down with weights. Partial fermentation sets in, and the watery juice rises to the surface. This expressed juice is after a time poured off, and water containing a solution of salt poured in, and changed from time to time till it ceases to rise with a scum and fetid smell. The cabbage is then fit for keeping, and is stored in the barrels, still under pressure, in cellars, and continues in excellent condition for use till late in spring. When used, it is washed with soft water, and stewed with bacon or salted meat, and is said to be very wholesome.

Saugh. One of the names of the Sallow *Salix caprea*.

Saul or **Sâl.** The Indian name of a valuable timber, much used in the East for building and engineering purposes. The tree which yields it is the *Shorea robusta* of botanists.

Saunders or Sandal Wood. The white or scented sandal wood produced by *Santalum album* and brought from the East Indies. When distilled with water, it yields a thick essential

oil smelling something like roses. Red saunders or sandal is the wood of the *Pterocarpus santalinus*, also a native of India. Its colouring matter is insoluble in water, but soluble in alcohol, and is used to impart a red tinge to certain tinctures. The resinous exudation of this tree constitutes one of the varieties of *dragon's blood*.

Saurians (Gr. σαῦρος, *a lizard*). The name of an order of reptiles, including all those which are covered with scales and have four legs, as the crocodile and lizard. The mouth of the saurians is always armed with teeth, and their toes are generally furnished with claws; they have all a tail more or less long, and generally very thick at the base. A few species, exceptions to the general character, have only two legs. The most gigantic and singular species of the Saurian order are now extinct.

Sauropterygia (Gr. σαῦρος, *lizard*, and πτέρυξ, *fin*). An order of Fossil Reptilia in which are no postorbital and supra-temporal bones: there are large temporal and other vacuities between certain cranial bones; a *foramen parietale*; two antorbital nostrils; teeth simple, in distinct sockets of the premaxillary, maxillary, and premandibular bones, rarely on the palatine or pterygoid bones; maxillaries larger than premaxillaries; limbs natatory; not more than five digits. An episternum and clavicles. A sacrum of one or two vertebræ for the attachment of the pelvic arch in some, numerous cervical vertebræ in most. Pleurapophyses with simple heads; those of the trunk long and bent. The genera *Nothosaurus*, *Pistosaurus*, *Conchiosaurus*, *Simosaurus*, *Placodus*, *Tanystropheus*, *Sphenosaurus*, *Plesiosaurus*, *Pliosaurus*, and *Polyptychodon*, belong to this order, which is found in all the strata from the trias to the chalk inclusive.

Saururaceæ (Saururus, one of the genera). A small order of Hypogynous Exogens, belonging to the Piperal alliance. They differ from *Piperaceæ* in the compound nature of their ovary, and in their constantly stipulate leaves. The species, which have no important properties, are natives of North America, China, and Northern India.

Saussurite. A compact variety of Epidote of a green or ash-grey colour, forming the Jade or Nephrite of the Swiss Alps. Named after De Saussure, by whom it was originally discovered in rounded masses on the borders of the Lake of Geneva. It is also found in Cornwall at Kynance Cove, Coverack Cove, and the Lizard; and in Scotland at Glen Tilt in Perthshire and Portsoy in Banffshire.

Sauvagesiaceæ (Sauvagesia, one of the genera). A small order of Hypogynous Exogens of the Violal alliance, found in South America and the West Indies.

Savannahs (Span. sabana) or **Prairies.** Vast tracts of plain land of small elevation, and generally covered with vegetation throughout most of the year. The prairie land of North America occupies at least two and a half millions of square miles. Part of it is heathy or bushy, part alluvial and wet, but the greater part dry and grassy. The savannahs of the Mississippi are grassy, and occasionally salt effloresces on the surface. The pine barrens of many of the Southern states are similar tracts, barren except for a growth of pine. The interior of Africa contains very extensive tracts of low plain covered with much vegetation, and the resort of large wild animals in enormous herds. These also are savannahs.

Savin (Lat. sabina). One of the species of juniper (*Juniperus Sabina*). It is a low evergreen shrub, of an acrid irritant nature, and possessing purgative, stimulant, and emmenagogue properties.

Savings Banks. The Savings Bank Acts were consolidated and amended by stat. 26 and 27 Vict. c. 87. At the end of 1864 the number of savings banks amounted to 578, and the aggregate amount of their deposits to thirty-nine millions and a half. In addition to these there were about five millions of deposits in the Post Office savings banks. [Bank, Savings.] (Dégerando, *De la Bienfaisance Publique*, vol. iii. 1. 2. ch. iv.)

Savitar. In Hindu Mythology, a name for the sun, as having a golden hand. Like the names Lykios, Lycaon, &c., the word denoted originally only the golden rays which shoot from the sun; but when the name was taken literally, the story grew up that the sun, offering up a sacrifice, cut off his hand, which was replaced by an artificial hand of gold. (Max Müller, *Lectures on Language*, second series, viii.)

Savory. [Satureja.]

Savoy. One of the hardier of the varieties of Cabbage, remarkable for its bullate or blistered leaves. It is the type of a race of subvarieties, included under the name *Brassica oleracea bullata major*.

Saw-wort. The common name for *Serratula*, a genus of Composites represented in this country by *S. tinctoria*, the herbage of which yields a yellow dye.

Saxifragaceæ (Saxifraga, one of the genera). A natural order of Perigynous Exogens, of herbaceous habit, chiefly inhabiting the mountainous regions of Europe and the northern parts of the world. They are nearly allied to *Rosaceæ*, from which they differ in having polyspermous, didymous, partially concrete carpels, and albuminous seeds, and in wanting stipules. The root of *Heuchera americana* is a powerful astringent, whence it is called in North America Alum-root; other species are pretty herbaceous plants.

Saxon Architecture. [Architecture.]

Saxon Blue. A solution of indigo in concentrated sulphuric acid: it is much used as a dye stuff.

Saxony Beryl. A name under which Apatite is sometimes sold by lapidaries.

Scabbard Fish. [Lepidopus.]

Scabinus. The Latinised form of the old German word schöppe, in French échevin.

Judicial officers of various descriptions in the middle ages bore this title, especially in the *communes*, or municipalities. See as to its history, Meyer's *Instit. Judiciaires*; *Mém. de l'Acad. des Inscr.* vol. xxxvii.

Scabrous (Lat. scaber, *rough*). In Botany and Zoology, when a surface is rough to the touch, from granules scarcely visible.

Scævola (Lat. from scævus; Gr. σκαιός, *on the left hand*). An extensive genus of *Goodeniaceæ*, almost peculiar to Australia and the Sandwich Islands. They are herbaceous plants or small shrubs; and one species, *S. Lobelia*, the Taccada of India and Ceylon, commonly found on the seashores of tropical Asia and the islands of the Indian and Pacific Oceans, has a thick succulent stem, full of pith, which is beautifully fine and white, and resembles that of the Rice-paper plant, with which it has been confounded. It is much used by the Malays and Siamese for making artificial flowers, small figures, and other articles used as decorations at feasts and on festivals.

Scaffolding. In Architecture, the temporary combination of timber-work, by the means of upright poles and horizontal pieces, on which latter are laid the boards for carrying up the different stages or floors of a building, and which are *struck* or removed as soon as they have answered their purpose. The scaffolding used for carrying up buildings on the Continent was formerly more scientifically and solidly constructed than that used in this country. But great improvements have latterly taken place in our practice; and instead of the poles lashed together with ropes which were formerly used, squared timber properly bolted is now employed, so as to constitute a framework that will carry a travelling crane on the top. This crane or winch is often now worked by steam.

Scagliola (Ital.). In Architecture, a composition; sometimes called also *Mischia*, from the mixture of colours employed in it to imitate marble. The Florentines claim the invention of this art, but it had been practised in Lombardy previous to its introduction at Florence. Lanza says that it was invented by Guido Sassi, who died in 1649, at Carpi, in the state of Modena, and that he commenced by executing cornices and other members of architecture which had all the appearance of the finest marbles; whereas its introduction at Florence was not till the middle of the eighteenth century. Scagliola is composed of gypsum or sulphate of lime, calcined and reduced to a fine powder, with the addition of which to water a fine paste is made. When columns are made with the composition, a frame or cradle is first formed, which is lathed round and coated with lime and hair, raised up in some parts with small projections. On this, when dry, is laid a composition consisting of pure gypsum, calcined and passed through a sieve, and, as wanted, mixed with glue or isinglass; it is floated with wooden moulds of the proper form, during which operation the colours, by which the imitation is obtained, are put on. When this is set, the work is smoothed with pumice-stone with one hand of the workman, while the other is employed in washing it with a sponge and water. It is then polished with tripoli, charcoal, and a piece of fine linen, and afterwards with a piece of felt dipped in oil and tripoli, and finished off with pure oil laid on with cotton wool.

Scalar (Lat. scala). In the language of Quaternions, a positive or negative number. [QUATERNION.]

Scald (Norse skálld). In the old Norse language, a poet. In the northern literature, those mythological poems of which the writers are known are properly called songs of the Scalds, while those of unknown authors are termed Eddas. It appears from Tacitus that the ancient Germans had those three classes of poems which were found at a later era in Scandinavia, namely, relating to the gods, to heaven, and to historical subjects. The Scalds whose remains have come down to us are very numerous. Their poems are partly alliterative, and partly rhymed; and this latter circumstance seems to indicate works of comparatively recent date. The historical value of their poems is considerable; but they are written in a peculiar vein of exaggeration, and in a metaphysical and almost enigmatical fashion, which appears to have been characteristic of the poetical art of the north. [EDDA; SAGA.] A list of the Scalds, with remarks on Scaldic poetry, is given in the *Fundgruben des Orientes*, vol. i.

Scale (Ital. scala, *a ladder* or *series of stairs*). In Mensuration, a line or rule of a definite length, divided into a given number of equal parts, and used for the purpose of measuring other linear magnitudes. The term *scale* is also applied to a mathematical instrument, consisting of an assemblage of lines and figures engraved on a plane rule, by means of which certain proportional quantities or arithmetical results are obtained by inspection. Of these the principal are the *plane scale*, the *diagonal scale*, *Gunter's scale*, &c. For the construction and uses of these various scales, see Robertson's *Description and Use of Mathematical Instruments*.

SCALE. In Music, a progressive series of sounds rising or falling through such intermediate degrees as create an agreeable and perfect succession, wherein all the harmonical intervals are conveniently divided. The diatonic scale has seven notes in each octave, the intervals being whole tones and semitones, arranged in the proper order according as the mode is major or minor; the chromatic scale has twelve notes, the intervals being all semitones.

SCALE. In Zoology, this name is properly applied to the plates, generally thin, small, and imbricated, which defend the skin of fishes. They are substances of different texture which are developed beneath the true epiderm, and

appertain to the system of the rete mucosum. The so-called scales of serpents and other reptiles are modifications of the epidermis, and are sometimes termed *scutes*. Fishes have been classified according to the structure of their scales. [CTENOID; CYCLOID; GANOID; PLACOID.]

SCALE. The hard crust of salt, lime, &c., which collects upon the inner surface of the plates of a boiler, when proper attention has not been paid to the *blowing off*. The hammers that are used for detaching this scale are specifically known as *scaling hammers*.

Scale of Notation. In Arithmetic, numbers are represented by *numerals* placed side by side, which numerals have an *intrinsic* as well as a *local* value. By the scale of notation is meant the order of progression of these local values. Thus, in the ordinary or *denary scale*, the value of the unit as we proceed from right to left increases in the ratio of one to ten. The ratio is called the *base* or *radix* of the scale. [ARITHMETIC.]

Scale of Relation. [RECURRING SERIES.]

Scales for Weighing. [WEIGHTS AND MEASURES.]

Scalene Triangle (Gr. σκαληνός, *unequal*). In Geometry, a triangle whose sides are unequal.

Scalenus (Gr. σκαληνός). A muscle of the neck, situated between the transverse processes of the cervical vertebræ and the upper part of the neck.

Scaling Ladders. Ladders made in parts of about twelve feet in length, which can be joined together by inserting the end of one portion in staples at the end of another, and securing them by lashings.

Scallop. A bivalve mollusc, the *Pecten maximus* of malacologists. An allied species, the *Pecten Jacobæus*, was much employed by pilgrims during the middle ages, as the emblem of St. Iago de Compostella. Many species of scallops are known, some of great size and beauty, which are found in the Pacific seas.

SCALLOP. In Heraldry. [ESCALOP.]

Scalpel (Lat. scalpare, *to carve*). A dissecting knife.

Scalpriform (Lat. scalprum, *a knife* or *chisel*). Certain teeth are so called, which have a cutting edge, preserved by a partial deposition of the enamel on one side: such scalpriform teeth are large, long, and curved, and are well exemplified in the incisors of the Rodent order.

Scalprum (Lat.). In Mammalogy, the cutting edge of the incisor teeth.

Scammony. In Pharmacy, the gum-resin of the *Convolvulus Scammonia*, chiefly imported from Aleppo and Smyrna in packages, called *drums*, weighing about 100 pounds each. It is of a dark olive colour, and when wetted and rubbed should easily form a milky solution: it is very apt to be adulterated, and an article entirely fictitious is often sold under the name of scammony. Scammony is an excellent drastic purge, and is generally administered in combination with other purgatives in doses of three or four grains, or more.

Scandalum Magnatum. In Law, an action which still lies, although for a long period it has never been resorted to, on the stat. 2 Rich. II. stat. 1, c. 5, and statute of Westminster the First, 3 Edw. I. c. 34, for words spoken in derogation of a peer, a judge, or other great officer of the realm; which need not be such as would be actionable at common law in the case of a private person. 'The duke of Richmond *v.* Castellow,' in the eighth year of Queen Anne, seems to have been the last instance of this species of action.

Scanning. In Prosody, the measuring of a verse by feet, according to the quantity of the syllables. [PROSODY.]

Scansorials (Lat. scando, *I climb*). Climbing birds. The name of an order of birds, including those which have the toes arranged in pairs, two before and two behind; a conformation of the foot which is well adapted for the act of climbing.

Scant. In Naval language, the term applied to the wind when it is barely fair.

Scantling (Fr. échantillon). In Architecture, the measures of breadth and thickness of a piece of timber or other material. It is also the name of a piece of timber when under five inches square.

SCANTLING. In Naval Architecture, the scale or dimensions of the breadth and thickness of the timbers. Thus two ships of different sizes may have the same scantling.

Scape (Lat. scapus, *a stem*). In Botany, a peduncle, which, in plants destitute of a stem, rises above the ground and supports the flowers upon its apex, as in the Cowslip.

Scape Goat. In the Levitical legislation, a live goat on which the high priest was enjoined to lay the iniquities of the Israelites, which the goat, being set free, was to bear into a land uninhabited. (Lev. xvi. 21.)

Scapellus (dim. of Lat. scapus). In Botany, the neck or caulicle of the germinating embryo.

Scapement or **Escapement.** [HOROLOGY.]

Scaphite (Gr. σκάφη, *a boat* or *skiff*). A genus of elliptical-chambered shells, belonging to the family of the Ammonitidæ, having the inner extremity coiled up in whorls embracing one another, and the outer extremity continued nearly in a horizontal plane, and then folded back, so as sometimes to touch the spire of the opposite end of the shell. The transverse plates are numerous, and are pierced by a marginal siphuncle at the back of the shell, and their edges are deeply cut and foliated. These beautiful shells, which thus resemble the ancient form of a boat, are almost peculiar to the chalk formation.

Scapolite (Gr. σκᾶπος, *a rod*, and λίθος, *stone*). A silicate of alumina and lime, originally from Arendal in Norway, the crystals of which are often collected in groups of parallel

diverging, or intermingled prisms (whence its name). It is generally of a pale colour; either white or grey, yellowish, blue, green, or red, and transparent or translucent.

Scapula (Lat. *the shoulder-blade*). In Comparative Anatomy, the bone which passes from the shoulder joint in a direction towards the vertebral column. It is broad and flat, generally triangular, sometimes subquadrilateral, in the mammalia; narrow, and commonly sabre-shaped, in birds; narrow and straight in Saurian reptiles; a round, strong, and straight column, in Chelonian reptiles; variously shaped, and articulated to the back of the skull in most fishes.

Scapulars or **Scapular Feathers.** In Ornithology, the feathers which take their origin from the shoulders and cover the sides of the back.

Scapulary (Lat. scapulæ, *the shoulders*). A portion of the dress of the monastic orders, consisting of two bands of woollen stuff, of which the one crosses the back or shoulders, and the other the stomach. According to the Abbé Fleury (*Mœurs des Chrétiens*), the scapulary originated with St. Benedict, and was a large and heavy covering of the shoulders, worn by the early monks in their rural labours for the convenience of carrying loads, and to protect the tunic. Simon Stock, an Englishman, general of the Carmelites in the thirteenth century, first introduced, under the authority of a vision, the notion that the scapulary is an especial sign of devotion to the Virgin Mary. The scapulary of lay persons consists of two little pieces of stuff on which the name of the Virgin is embroidered.

Scapus (Lat.; Gr. σκᾶπος, Doric form of σκῆπτρον, *a shaft* or *stalk*). In Architecture, the Shaft of a column.

Scapus. In Ornithology, the stem or trunk of a feather, including the hollow base or quill, *calamus*, which is inserted into the skin, and the solid exserted stem supporting the barbs, or *rachis*.

Scarabæidans (Lat. scarabæus). The name of a family of Coleopterous insects, of which the genus *Scarabæus* is the type; it corresponds with the great tribe of Lamellicorns.

Scarabæus (Lat.; Gr. σκάραβος, and κάραβος, *a beetle*. The word is akin to Sansc. çarabha, *a locust*; Ger. krebs; Eng. crab). The use and meaning of the scarabæus, as a symbol, are, as yet, among the mysteries of archæological science. The Egyptians, it is said, found in it an emblem of the world instinct with the seeds of life; because the kind of beetle represented by it forms a ball of earth in which to deposit its eggs. It is also called a type of the sun. However this may be, it was habitually worn by the ancient Egyptians and Etrurians as an amulet. The ancient Egyptian scarabæus was plain, or inscribed with characters; and was made of opaque stone, basalt, or porphyry. The Etrurian scarabæus (found in quantities in the sepulchres) was of semitransparent stone, cornelian, onyx, sardonyx, agate, or jasper. Lastly, the modern Egyptian scarabæus of Roman times was generally of precious or semi-precious stones, and rudely engraved, and seems to belong to an age when, the religious use of the scarabæus being forgotten, it was retained only as an ornament.

Scaramouch (Fr. escarmouche, Span. escaramuza, Ital. scaramuccio, *skirmish*). A personage in the old Italian Commedia dell' Arte, dressed in the Spanish or Hispano-Neapolitan costume, and representing a military personage, a poltroon and braggadocio, who always ended by receiving a beating from the hands of Harlequin. The most celebrated Scaramouch of the Italian theatre at Paris was Tiberio Fiurelli, a Neapolitan, whose agility was such that he was able, according to his biographers, to give a box on the ear with his foot at the age of eighty.

Scarbroite. A clay-like mineral found in a calcareous rock near Scarborough (whence the name) in Yorkshire, between septa of ironstone. It is a hydrated silicate of alumina, and occurs in amorphous, pure white masses which are devoid of lustre and give off a strong argillaceous odour when breathed on.

Scarfing. In Architecture, the formation of a beam out of two pieces of timber; usually employed when it cannot be conveniently procured in one length. It is usually performed by cutting the ends obliquely, indenting the faces where they are joined to each other, and bolting them through the tapering ends when brought together.

Scarfskin. The cuticle or epidermis. [Skin.]

Scarificator (Lat. scarifico, Gr. σκαριφάομαι, *I scrape* or *scratch*). An instrument used in cupping; it consists of ten or twelve lancets, which are discharged through apertures in its plane surface by pulling a kind of trigger, so that in passing they make a number of incisions in the part to which the instrument is applied.

Scarlatina or **Scarlet Fever.** This highly contagious disease assumes several different forms. These are ushered in with fever varying in intensity, sometimes very slight, occasionally violent, but in some forms of the disease adynamic from the commencement, and apparently indicative of the action of an animal poison. In most cases a scarlet efflorescence appears on the second day upon the skin, and in three or four days the cuticle peels off in branny scales. Old writers speak of the fourth day for the appearance of eruption, but it is not so. The throat, though generally severely involved, may escape altogether in mild cases, but in the virulent forms of the disease it may become inflamed, livid, and even gangrenous.

Scarlatina, even in its mildest forms, is occasionally followed by general dropsy, but this condition admits of relief.

Scarlet fever is distinguished from measles by the greater extent and want of elevation of the eruption, and by its not congregating into semilunar patches; nor is there the cough, and

running from the eyes and nose, which usher in the measles. It seizes persons of all ages, but children and the young are most subject to it. It appears at all seasons of the year, and in autumn is often epidemic. It may attack the same person more than once. The malignant sore throat of the older writers (*cynanche maligna*) is nothing else than scarlatina in its worst form, and in which the virulence of the disease is extended to the throat.

Scarlet Oak. *Quercus coccinea*, the leaves of which turn red in dying.

Scarlet Runner. The *Phaseolus multiflorus*, which is extensively cultivated in this country as an esculent. [PHASEOLUS.]

Scarp. [ESCARP.]

Scarus (Lat.; Gr. σκάρος). The Parrot-fish, so called, in which the dental apparatus is developed in a bony beak. The species so called by the ancients exists in the Mediterranean.

Scelides (Gr. σκέλος, *a leg*). In Mammalogy, the lower, posterior, or pelvic extremities.

Scelotyrbe (Gr. σκελοτύρβη, *lameness in the leg*). A disease described by Galen, in which a man is incapable of walking straight forward, and drags the foot: it is generally regarded as a species of Chorea, or St. Vitus's dance.

Scene (Gr. σκηνή, *a covered place*). In Dramatic Literature, the imaginary place in which the action of the play is supposed to pass; also a division of a drama: properly speaking, whenever the action changes to a new scene or place. But in the French theatre, and those framed on its model (in which unity of place is observed), every entry of an actor constitutes a new scene. On the English stage, the subdivision called a scene is extremely arbitrary; the scenes in most plays being far more numerous than the actual changes of scene, while at the same time the French rule is not observed, and actors enter in the middle of a scene. The scenes in a play are numbered as subdivisions of the act. [ACT.]

Scene Painting. A department of the art of painting, governed by the laws of perspective, applied to the peculiar exigencies of a theatre. It is conducted chiefly in distemper or water colours, and admits of the most striking effects, which indeed, in scene painting, is almost all that is required.

Scenery (Gr. σκηνή, *a covered place*, hence a stage: in modern Greek the word has acquired the meaning attached by us to the term *scene*). The appearance of a place or of objects, or the representation of a spot wherein an action is performed. [LANDSCAPE.]

Scenery, Celestial. [SIDEREAL SYSTEM; SOLAR SYSTEM.]

Scepaceæ (Scepa, a name of one of the genera). A group of Diclinous Exogens, referred by Lindley as a separate order to the Euphorbial alliance, and by others united with the *Euphorbiaceæ*. The characters relied on for their separation are, the amentaceous male flowers, the definite suspended anatropal ovules, and the superior radicle. *Scepa*, the typical genus, is now merged in *Aporosa*.

Scepticism (Gr. σκεπτικός, *thoughtful*). In the History of Philosophy, a name sometimes given to that tendency of thought or system of doctrines the object of which is, by denying the existence of all grounds of knowledge, to introduce universal doubt and suspension of assent. Schools of scepticism have existed at several different periods in the progress of philosophical enquiry. The first who received or adopted the name was Pyrrho, who taught in Athens about the year 300 B.C. Our chief notices of his opinions are derived from the writings, in verse, of his disciple Timon, preserved to us by Sextus Empiricus. He was led to his sceptical views partly by the contradictions observable in the impressions on our senses, and partly by the incompatibility of the principles of different schools with each other. To a complete suspension of judgment in speculation (ἐποχή) he united a corresponding state of indifference in feeling (ἀταραξία), and made virtue and happiness to consist in the absence of mental perturbation. Either he or his scholars endeavoured to present a synopsis of their sceptical views in ten general forms, or commonplaces, all of which, however, may be included in one or other of the two sources of doubt mentioned above.

The school of Pyrrho seems to have expired with his disciple Timon; though many of his views were espoused and maintained by the later academy. [ACADEMICS.] About the middle of the third century of the Christian era, we meet with a school known as that of the later sceptics. This sect seems to have originated with one Ænesidemus, a physician. It was, in fact, a school of physicians, who, in opposition to the *Methodic* sect, adopted a strictly empirical mode of treatment, and sought in sceptical considerations a justification of their practice. The grounds of this scepticism have been recorded by Sextus Empiricus. It regarded not so much the validity of the notices given by the senses (to which their empirical method imposed on them a necessity of yielding their assent), as the general form and method of science. Syllogism they regarded as utterly void, inasmuch as the conclusion must have been contained in the induction on which the major proposition was founded. Perfect induction was impossible; imperfect induction was unsatisfactory. They also attacked, with considerable acuteness, the received doctrines of cause and effect, and of the nature of God; chiefly in opposition to the Stoics, the most dogmatical of the ancient sects. Their morality, like their speculative creed, was a system of mere sensualism. This school may be considered as the last purely Grecian sect. After them an Oriental element was introduced into philosophy, which materially altered its character and bearing. The most celebrated sceptics of modern times are Montaigne (A.D. 1580); Glanville, an English-

man, who flourished about the period of the Restoration; Bayle, and Hume. According to Hume, all the objects of consciousness may be reduced to two classes: 1. the impressions on the senses; and, 2. ideas or copies of those impressions, which differ from their original only in being less vivid. All knowledge, save that of mathematical relations, consists in the arrangement of these impressions according to the order of their succession. Of the connection between any two links of this succession, we know nothing; that to which we give the name causation being, in fact, nothing more than habitual sequence relatively to the phenomena, and custom, or often-repeated association, in relation to ourselves. All enquiry into things in themselves, or their grounds—in other words, all metaphysical speculation, is consequently founded on delusion. The writings of David Hume, which contain his sceptical speculations, are his *Treatise on Human Nature*, and the early part of the second volume of his *Essays*. (Ritter, book x. ch. i.; Hallam, *Literary History*, part ii. ch. iii.)

Sceptre (Gr. σκῆπτρον, *a staff to lean on*). A well-known emblem of sovereignty. Achilles swears by his staff or sceptre in the first book of the *Iliad*. Tarquin the elder is said to be the first who assumed the sceptre among the Romans. According to Justin, it was originally a spear. The sceptre of the Merovingian kings, as represented on monuments, is a rod, probably of metal, of the height of the bearer, and slightly curved like a crosier.

Schaalstein. A Mineralogical synonym of *Table Spar* (Tafelspath of the Germans). [Wollastonite.]

Schapziger. A kind of cheese made in Switzerland, to which the coumarin flavour of *Melilotus cœruleus* is communicated.

Schedule (Lat. dim. of scheda, Gr. σχίδη, *a piece cut off*, hence *a leaf of paper*). In the language of English Jurisprudence, this term is commonly used to signify some smaller document attached to a larger one and forming for legal purposes part of it; as the *schedule* to an Act of Parliament, in which various particulars to which the general provisions of that Act relate are enumerated; the *schedule* or inventory of goods attached to documents dealing with them; and so forth.

Scheele's Green. A green pigment obtained by mixing arsenite of potassa with sulphate of copper. It is an arsenite of copper, and much used as an oil and water colour, and more especially for paper-hangings: but the frequent occurrence of its mischievous effects when thus employed has lately thrown it into disrepute. 'From a shop the walls of which were covered with arsenical paper, I procured some dust which yielded a large proportion of arsenic. In another case arsenic was found in the dust on the cornices and picture frames. It is therefore obvious that the atmosphere of rooms may thus be contaminated, and the poisonous particles received into the lungs, and though the quantity thus imbibed at any one time may be small, it is certainly not advisable that, merely for the sake of a green colour, persons should be exposed to breathe arsenic day by day.' (Taylor *On Poisons*.)

Scheeletine. Native tungstate of lead, composed (when pure) of 51·7 per cent. of tungstic acid, and 48·3 lead. It occurs in faintly translucent four-sided prisms, which are colourless or of a yellowish-grey, brownish, or green colour, in the tin-mines of Zinnwald in Bohemia, at Bleiberg in Carinthia, and near Coquimbo in Chili. Named after the Swedish chemist Scheele.

Scheelium. A name sometimes applied to tungsten, in honour of Scheele, who discovered it.

Scheererite. A mineral resin found in loosely aggregated, feebly shining, crystalline grains and folia, or in minute acicular crystals with a yellowish or greenish tinge, in small cavities in Brown Coal at Utznach in Switzerland, and in Denmark in peat-mosses. Named after the discoverer, Colonel von Scheerer.

Scheiks. The hereditary chieftains of the Arab tribes. The descendants of Mohammed hold the highest rank among the scheiks, and are distinguished from the other chiefs by the title of Sherif.

Schelling, The Philosophy of. This philosophy teaches the identity or *indifference* of the ideal and real. Its author, Frederick Wilhelm Joseph von Schelling, was born Jan. 27, 1775, and studied successively at Tübingen, Leipzig, and Jena. In the latter place, he was a pupil of Fichte. In 1841 Schelling went to Berlin, where his lectures excited the most lively interest. He died in 1854.

It is extremely difficult to understand the true significancy of any particular system of philosophy, if it is considered in itself, and apart from its connection with the general history of philosophy. This general truth is particularly applicable to the philosophical developement of Germany, the unity of whose literary pursuits seems to supply the want of a true political unity. The concatenation of views and opinions, from Leibnitz and Spinosa to the philosophers of the present day, is easily traceable; but it will be sufficient for the elucidation of Schelling's philosophy to begin with the critical theory of Kant. The transcendental idealism of this philosopher formed the transition from the empiricism of the eighteenth century, and effected, as it were, a compromise between the scepticism of Hume and the realism to which it succeeded. Without denying or asserting the existence of a material world, Kant was content with confessing an ignorance, at all events, of its nature. In his view, all that man can know of outward objects is, that they furnish the material ground of his conceptions. Of things themselves, or, as Kant calls them, of phenomena, man absolutely knows nothing; all that he can do is to note the modes under which they appear to him.

But while the criticism of the pure reason seemed to lead to a speculative idealism, that of the practical reason appeared to possess a mystical tendency. This tendency of the Kantian philosophy was worked out by Haman and Herder, but found its culminating point in Jacobi's Philosophy of Faith, which had many adherents in Germany, and extensively influenced the prevailing ideas of philosophy. According to Jacobi, the end and aim of true philosophy is a knowledge of God. Now, the pursuit of this object must set out from feeling and intuition, for there is no speculative method which can give a demonstration of God; for God is infinite, but the understanding finite; and all mediate knowledge by reasoning, which is a procedure of the intellect, cannot attain to the infinite. Reasoning, moreover, cannot do more than establish the correspondence of certain identical propositions from which it passes, step by step, and on the presumption of whose truth it proceeds. The element, therefore, of all human knowledge is faith; an original instinct of man's nature, which immediately reveals to him the divine; and, in spite of any suspicions of the validity of sensuous testimony, enforces a belief in the existence of an external world. The philosophical merits of Jacobi consist in this, that he did not, with Kant, regard God as a mere abstraction, but as a living spirit, whose presence is manifest within man himself; and further, in the way that he insisted on the validity of the immediate perceptions of consciousness, in opposition to the absolute authority of the finite understanding. However, true philosophical science cannot admit of any such contrariety of intellect and feeling; and to establish their identity, or at least to combine them in unison, was the problem which Fichte attempted to solve. Fichte's philosophy is marked chiefly by the way in which he carried, to its extreme result, the idealistic tendency of Kant. In the *Wissenschaftslehre* we have a system of pure and absolute idealism. The existence of a material world is here denied unconditionally; the real exists only so far as it is necessarily conceived by us; so that the external world is purely a creation of our conceptions, and the real is a product of the ideal. To use the language of Fichte, the ego is absolute, and posits itself; it is a pure activity. As its activity, however, has certain indefinable limits, when it experiences this limitation of its activity it also posits a non-ego, and so originates the objective world. The ego, therefore, cannot posit itself without at the same time projecting a non-ego; which, consequently, is in so far the mere creation of the ego. With the mediate knowledge of reflection, by which Fichte attained to this speculative result, he combined for practical ends the authority of immediate consciousness. As, he argued, it is from the impulse of the ego to activity that the non-ego arises, the absolute ego stands to the intelligent ego in the relation of a cause to its effect. But although the absolute practical ego is absolutely free, and the sole principle of all reality, so as to posit the world in opposition to itself, and to be its cause, it has, nevertheless, a subjective limit to its operation. This is the idea of duty which the consciousness immediately announces to man as an unconditional authority and obligation; which, however, is not subversive of the freedom of the ego, but is simply an impulsive motive to its activity. Now, so far as the ego attempts to realise this duty, it tends to a moral order. He who does his utmost to establish this moral order, comes near to the Deity, and enters upon his true and proper life.

Such was the point to which speculation had attained when Schelling appeared as a philosophical writer. The subjective thought had been made the supreme and only principle, before which all objective entity was driven into the background; and the subjectivity of the idea was the only real existence acknowledged. For this subjective idealism Schelling, however, did but substitute an objective idealism, by giving objectivity to the idea itself, and declaring every entity to be also rational thought. Kant had spoken of the objective as unknowable; Fichte had denied its existence; and Schelling identified the ideal and the real. Fichte had confined himself to giving a derivation of nature and its laws out of an absolute and spontaneous activity of the ego. Schelling maintained that not only must the laws of consciousness be immediately cognisable in the objective world, as laws of nature; but conversely, also, the laws of nature must be immediately demonstrable in the consciousness as laws of the subjective. Man finds himself in nature, and nature in himself. Besides Fichte's method, therefore, of descending from the ego, Schelling held it to be necessary to ascend from nature up to ego. The former method is given in his transcendental philosophy, the latter in the *nature-philosophy*, which make up his system of identity. The general principles of this system are as follows: That true and perfect science, which it has always been the object of philosophy to realise, must be one which has its authority in itself, embraces all things, and is perfectly correspondent to its object; for truth is impossible without a perfect agreement of the knowing and the known. Now, as all philosophy must proceed on the assumption that the cognisant mind is capable of true cognition, it follows that the knowing subject cannot, in its essence, be opposed to the object known; and that, consequently, it must be possible to know the real essence of things. The essence, therefore, of that which thinks and that which exists, of thought and entity, soul and body, is one and the same. By means of this essential oneness, or, in the terminology of Schelling, of this absolute identity and in-

difference of thought and being, the ideal and real, and in consequence of the mind being, in substance at least, homogeneous with things without it, the former is capable of representing in cognition the latter, such as they are in truth and in their essence. The knowledge thus gained is a pure intellectual intuition; it is not mere reflection, which, by its nature, cannot go beyond its data. Rising above phenomena to the ideas of the absolute, which is their identical origin, it is able to apprehend the essence of things. It is, however, by reflection that man becomes conscious of these ideas through the aid of the senses; and this art of unfolding ideas by reflection constitutes Dialectics. One of the duties of this art is to trace the identical principle in its regular developement, and to determine every branch of knowledge, in relation not only to the fundamental idea of the truth, but also to the cognate sciences. The true method of philosophy is the method of construction, and without it no safe step can be taken in speculative science. This method is to become fully conscious of the laws of mind, which are inherent in it; and, agreeably to them, to shape every special science conformably to the existence of things. By such a method philosophical science is possible; and this is a science of the existent agreeably to the ideas (*Wissenschaft von Ideen*), i.e. a science of God, and of His relation to the world, and of man and nature. According to the *nature-philosophy*, the Absolute, or God, is both thought and entity, without either unity or difference, out of which all contrariety has proceeded, and into which it will again return. As the Absolute is the sole and eternal essence of all things, every true entity, and therefore nature also, is divine, without a participation in which there can be no existence. In the eternal generation of things, the Absolute has revealed itself in infinite ways in space and time. This revelation is a living developement of the infinite according to certain contraries of the subjective and the objective, the ideal and the real. These contraries strive to combine together in different proportions, and so acquire different names, according to the varying preponderance or polarity of the ideal and real. Things, consequently, are not different in their essence, but merely quantitatively, or in degree. The preponderance of the objective constitutes unconscious nature: that of the subjective is spirit. The more complete the combination of these contraries, the more perfect are the objects. The most perfect union of them, or their absolute indifference, is found in the universe; and this complete identification and reunion of them is the full revelation of God. Man, lastly, is a copy of the universe (*microcosm*), in so far as, in a manner of his own, he unites together the ideal and the real.

The philosophy of Schelling appears, then, to be directly opposed to that of Kant, from which, however, it is directly descended not only in the nature of the knowledge which it assumes to be possible, but also with respect to the objects of that knowledge. In its essence it pretends to give a true image of the object known, and embraces, therefore, both nature and the world of man and spirits. In its method of exposition, also, it pretends to imitate the true course of the developement of nature, in which everything passes by coherent and successive steps (or *powers*, A, A^1, A^2, &c.) from the undeveloped to the developed and the perfect; and, beginning from the lowest grades of entity, passes to its higher developements.

Such is an outline of the system of Identity, as propounded by Schelling upwards of forty years ago, and which has exercised so important an influence on the mind of Germany. There is, however, good reason to believe that the opinions of its author were in his later years materially modified.

A brief statement of the manner in which the theory of Schelling was further modified by Hegel may be appended here, and will complete it as a general view of the modern philosophy in Germany. In the *Encyclopædia of Philosophical Sciences*, which Hegel published in 1817 at Berlin, and designed as a manual for the use of his class, he gives a general view of his system, and clearly exhibits its ultimate tendency. 'Logic,' he says, 'is the basis of ontology.' The idea in itself and potentially is the primary substance, but *in actu* it passes into the real. The ideal is to be examined, 1st, subjectively, as it exists in the mind; 2nd, objectively, or in *other*, i.e. in its outward manifestation; and 3rd, absolutely, as it is realised in art, religion, and philosophy. Schelling had made triplicity in unity to be the law which the principle of identity follows in its outward developement, and this trinary law forms also a conspicuous element of the Hegelian system. Thus he makes thought to be threefold: 1. *Formal thought*, which is independent of all subject matter, or, in the language of Hegel, of *all contents*; 2. The *notion*, or thought more fully determined; 3. The *idea*, or thought in its totality and fully determined. The last is the concrete, which is a self-developing and organical system, containing in itself all *momenta* or germs of further developement. Philosophy is the right evolution of this concrete, and its true method is the dialectical momentum. The history of philosophy, apart from its accidental media of schools and professors, is nothing less than the actual developement of philosophy itself. The several systems successively recorded are but so many gradations of progress, and the latest system is the sum and perfection of all anterior ones. Thus the theories of Schelling and Hegel are essentially based on the same principle, the absolute identity of thought and being. According to the former, the mind is in full possession both of truth and reality, the knowledge of which it attains by self-conscious-

ness, in the intellectual intuition. For the latter, Hegel substituted his *dialectical momentum*, or the logical developement of the idea. (Michelet, *Geschichte der letzten Systeme der Philosophie in Deutschland*; Jacobi, *Briefe über die Lehre des Spinosa*; Fichte, *Die Wissenschaftslehre*; *Die Bestimmung der Menschen*; Schelling, *System des transcendentalen Idealismus*; Bruno, *Oder über die göttliche und natürliche Princip. der Dinge*; Hegel, *Phenomenologie des Geistes*; *Encyclopædie der Philosophischen Wissenschaften*. For some of the more recent views attributed to Schelling, see Stahl's *Philosophie des Rechts nach geschichtlicher Ansicht*, *&c. &c.*)

The Hegelian philosophy, as a whole, has been recently brought before English readers in Mr. Stirling's *Secret of Hegel*.

Scheme (Gr. *σχῆμα*). A plan or representation of any geometrical or astronomical figure; a diagram.

Schererite. [Scheererite.]

Scherif (Arab. *lord* or *master*). A title given in the East, by prescriptive usage, to those who descend from Mohammed through his son-in-law and daughter, Ali and Fatima. They are also called Emir and Seid, and have the privilege of wearing the green turban. [Emir.] The chiefs of Mecca and of Medina, who are always supposed to belong to this sacred family, are styled the scherifs of those cities.

Scheroma (Gr. *σκηρός*, another form of *ξηρός*, *dry*). A dryness of the eye, arising from a deficiency in the secretion of the lachrymal glands.

Schiah. [Sunniah.]

Schiller Spar. A hydrated silicate of magnesia, in which a large proportion of the magnesia is replaced by the protoxides of iron and manganese, and by lime. It occurs granular and massive, of an olive-green or pinchbeck-brown colour and with a shining semi-metallic lustre, at Baste in the Harz, in compact Schillerstein, and in Euphotide.

Schinus (Gr. *σχῖνος*, *the mastic-tree*). A genus of *Anacardiaceæ*, consisting of trees and shrubs, natives of tropical America, &c., having unequally pinnate leaves, which in some of the species are so filled with a resinous fluid, that the least degree of unusual repletion of the tissue causes it to be discharged. Some of them fill the air with fragrance after rain; and *S. Molle* and some others expel their resin with such violence when immersed in water as to have the appearance of spontaneous motion, in consequence of the recoil. *S. Areira* is said to cause swellings in those who sleep under its shade. The fresh juicy bark of this shrub is used in Brazil for rubbing newly-made ropes, which it covers with a bright dark-brown varnish. The juice of this plant is used in diseases of the eyes. The root of *S. Molle* is used medicinally in Peru, while the resin that exudes from the tree is employed to astringe the gums. The specific name *Mollé* or *Mulli* is an adaptation of the Peruvian name for the shrub.

Schirrus (Gr. *σκιρρός*, or *σκιρός*, *dry*, *hard*). An induration of a gland, forming an indolent tumour, not readily suppurating, and at first unattended by discoloration of the skin.

Schism (Gr. *σχίσμα*, from *σχίζω*, *I cleave*). Separation from an organised society. The term is generally applied by the members of ecclesiastical or theological bodies to persons separating from their own communion. Thus, the chief schisms enumerated by Roman Catholic authorities are those of the Novatians, the Donatists, the Luciferians, the Greek church, and the Protestants. The great schism of the West in the fourteenth century holds also an important place in the history of the Papacy. [Antipope.]

Schisma (Gr. *σχίσμα*). In Music, an interval equal to half a comma; hence eighteen of them are required to make a complete tone.

Schist (Gr. *σχιστός*, *cloven*). Schists are fissile rocks greatly metamorphosed and generally having imperfect cleavage. Their basis is more silicious than argillaceous, and if the salts of alumina are present, they exist, not as clay, but as new combinations. Thus we have micaceous schists, chloritic schists, garnet schists, &c. Schists occur geologically with metamorphic rocks, overlying or interstratified with gneiss and even granite. They differ from slates in being imperfectly fissile, and from shales in being perfectly metamorphosed. They are very abundant in mountainous countries, sometimes forming the entire mountain mass, but more frequently flanking a granite nucleus. They often contain metalliferous veins; but rarely have any other economic value, not being readily dressed to a smooth surface, and not answering the purpose of either stone or slate for building. As rough stones, they are not uncommonly made use of for walling. [Chlorite Schist; Gneiss; Mica Slate; Slate.]

Schizandraceæ (Schizandra, one of the genera). A small order of Diclinous Exogens, referred by Lindley to the Menispermal alliance; in which it is known by its hypogynous stamens, pendulous seeds, and minute embryo enclosed in copious solid albumen. The order is by some botanists regarded as a tribe of *Magnoliaceæ*, distinguished from true *Magnoliæ* chiefly by their climbing habit, want of stipules, and unisexual flowers. They extend over tropical and Eastern Asia and North America.

Schizopods (Gr. *σχιζόπους*, from *σχίζω*, *I divide*, and *πούς*, *a foot*). The tribe of long-tailed Decapod Crustaceans, including those which have the legs slender and filamentous, accompanied by an external articulated branch as long as the limbs, which thus appear doubled in number; fitted for swimming, and not cheliferous, the eggs being carried beneath them, and not under the tail. The opossum shrimps (*Mysis*) are examples of this tribe.

Schmidelia (after C. C. Schmidel, a professor of botany at Erlangen). A genus of *Sapindaceæ* distributed through the tropics of

both hemispheres, consisting of trees or shrubs. The fruits of *S. africana* form one of the many remedies employed in Abyssinia against the tapeworm. The dried fruits are pounded and mixed with flour, and then made into cakes. The sweet pulpy part of the fruit of *S. edulis* is eaten in Brazil, where the fruits are called Fruta de Paraô; but the seeds of most of the genus possess unwholesome properties, and those of *S. Cobbe*, a Cingalese species, are reputed to be poisonous.

Scholarship. The common appellation, in the two English universities, of foundations in colleges, inferior to fellowships, but superior to 'exhibitions,' for the maintenance of scholars under certain regulations. Also in the universities themselves, as rewards of proficiency. Since the issue of the royal commission for enquiring into the state of the universities, the scholarships in the colleges of Oxford have been rendered entirely free from preferences in respect of kindred to the founders; there are also very few subject to preferences in respect of place of birth. The great majority, therefore, are open to all candidates below a fixed age, which in some colleges is nineteen, in others twenty. It should be mentioned, that in some colleges, some of the scholarships are set apart for candidates from certain schools. The elections to scholarships are decided by an examination of the candidates; and the subjects of examination are, in the majority of cases, the Latin and Greek languages. Some scholarships are given for attainments in mathematics, and in physical science. [BURSARS.]

Scholastic Philosophy. That method of philosophising which arose in the schools and universities of what are commonly called the dark ages. The father of the schoolmen was John Scotus Erigena, a native of Ireland, who lived in the ninth century. He first introduced among his contemporaries (it is not known from what source) the philosophy of Aristotle, which he combined with the doctrine of the new Platonists, and out of the combination constructed a complete system of Pantheism. These speculations were at first regarded by the church with an evil eye; nor was it before the expiration of the following century that they were applied to the purpose of explaining and supporting the leading facts of Christianity. It was probably the necessity which was felt of combating heretics with their own weapons, that caused the universal adoption of the Aristotelian philosophy by the great religious authorities of the day. It is at any rate certain, that the subtlety and ingenuity of the early schoolmen were confined to the task of constructing a scientific basis for the doctrines of the church out of the materials afforded by that system. The scholastic philosophy may be said to have expired with the conclusion of the fourteenth century, at least as to its influence on the leading minds of the age. Four distinct periods have been observed in the course of its developement; the first beginning with its earliest commencement, and including the names of Berengarius, Lanfranc, Anselm, and Hildebert. The second era commences with the rise of the sect of Nominalists, the founder of whom was Johannes Roscellinus, and their most distinguished member the celebrated Peter Abelard. The third period is marked by the introduction into Europe of the writings of the Arabian philosophers, and the translation into Latin of their versions of Aristotle's writings, with the complete ascendency of REALISM, and the now undisputed supremacy of Aristotle. The greatest names in this period, which embraces nearly all the thirteenth century, are those of Albertus Magnus, Thomas Aquinas, and Duns Scotus, with the respective followers of the two latter, the Thomists and Scotists. The glaring realism of Scotus roused the independent spirit of an Englishman, William of Ockham, to a closer investigation of the internal conditions of thought, and in him led to what may be considered a transition state between the formation of the old schoolmen and the tendency towards nature and experience which distinguishes modern speculations. The acuteness of this man restored the victory to the Nominalists. His nominalism, however, differed from that of Roscellinus and Abelard in the admission that 'universals' have a foundation of reality in the subjective conditions of the intellect, though not an outward nature; whereas, according to the former, a general term was a name only—a *flatus vocis*.

The scholastic theology, to adopt the definition of Hallam (*Introduction to the Literature of Europe in the Fifteenth, Sixteenth, and Seventeenth Centuries*), was, 'in its general principle, an alliance between faith and reason; an endeavour to arrange the orthodox system of the church, such as authority had made it, according to the rules and methods of the Aristotelian dialectics, and sometimes upon premisses supplied by metaphysical reasoning.' The scholastic philosophy, according to the same author, seems chiefly to be distinguished from this theology by a larger infusion of metaphysical reasoning, or by its occasional enquiries into subjects not immediately related to revealed articles of faith. There can be no doubt that the sudden rise and expansion of the scholastic method was favourable to the growth of mental vigour and illumination; since it substituted rigid reasoning, although on premisses for the most part fanciful, for that mere acquiescence in authority which had distinguished the theology and the scanty remnant of philosophy which subsisted in the ages immediately preceding. France, Germany, England, and at one period Spain, were the principal seats of the scholastic controversies: in Italy they had less influence. Our own island has indeed the honour of having produced an unusual proportion of the chief names in this department of literature. The best known among these are Duns Scotus, before mentioned; and William of Ockham, one of the last of the distinguished schoolmen

who flourished in the fourteenth century. In the fourteenth century, the dialectic method of the schools was applied by some learned legists to the science of jurisprudence. Bartolus and Baldus have the highest reputation among the scholastic jurists. (Milman, *Latin Christianity*, book xiv. ch. iii.; Tennemann, *Geschichte der Philosophie*; Hampden, *Bampton Lectures*, 1833.)

Scholiasts (Gr. σχολιαστής). The name given to the old grammarians, or critics, who used to write annotations, called *scholia* (the fruits of σχολή, or leisure), on the margin of the manuscripts of the classical authors of antiquity.

Scholium (Gr. σχόλιον). In Geometry, an explanatory observation, or excursive remark, on the nature and application of a train of reasoning.

Schools of Design. Government art schools, first established in 1837 at Somerset House, in consequence of the recommendation of a Committee of the House of Commons on 'Arts and their connection with Manufactures,' made in 1836. The object was to give a suitable education in art to designers employed or wishing to be employed in our factories in those departments of manufacture in which beauty of design constituted an essential element. By degrees branch schools were established in the various provincial towns dependent on manufactures, in connection with the head school at Somerset House. The principal branches were at Manchester, Sheffield, Nottingham, Birmingham, Newcastle, Glasgow, and Belfast. Eventually the branches became very numerous. Differences of opinion arose as to whether the education should be special or general. The common-sense principle has finally prevailed: the art education given is theoretical and general, so that the students, instead of being confined to any narrow specialties of education, are so taught as to be able to adapt themselves generally to such specialties as may be required from them in the various towns in which they settle and find employment. The principles of art are the same in all manufactures; it is only the application that is special, and this can be best learnt in the factory. The thoroughly educated art student can apply himself to any art manufacture, though some may limit their labours more especially to modelling in the round, while others will devote themselves to designing in the flat.

In 1852, the head school was removed from Somerset House to Marlborough House, where it changed its name into a Department, that of 'Practical Art.' This very vague title, however, was soon dropped, in favour of that of 'The Department of Science and Art;' and, from being under the control of the 'Board of Trade,' it was transferred to the direction of the 'Committee of Council on Education,' under which it now is, in its own extensive premises at South Kensington, whither it was removed from Marlborough House in 1857.

The Central School of Art at South Kensington has gradually become subordinate, as regards the public, to the Art Museum established there, which is gradually assuming gigantic proportions. At this central school, however, a very good art education is to be had, not only for designers for manufactures, but for artists and architects also. The entire fees amount to 10*l.* per annum. A good art library is attached to the school and museum. See the various *Parliamentary Reports*, and other official papers, from the year 1836 to the present time.

Schools, Free and Endowed. Schools in which elementary education in the classical languages is afforded, according to the intentions of the founder. A few among these have acquired, in popular phraseology, the designation of public schools. Nearly 500 are described by Mr. Carlisle in his work on these institutions.

The common notion, that a free school means a place of gratuitous education, cannot be maintained. Dr. Kennedy has shown (*Schola Libera*, 1862) that schools thus entitled are such as are free from the authority or supervision of colleges and chapters. At the Reformation, Edward VI. founded many such free schools, in order to counteract the influences of the religious bodies under which the education of the country, and particularly of those who were destined for service in the church, almost wholly lay. Thus Eton, Winchester, and Westminster, are still collegiate schools. At Canterbury, Ely, and elsewhere there are cathedral schools; and in these schools the education is partly or wholly gratuitous: but whether such be statutably the case with the free schools or not, the term *libera* certainly has no such meaning either in classical or mediæval Latin. The free schools, established by Edward VI. and by private founders after him, as by Lyon at Harrow, Sherriffe at Rugby, &c., are generally grammar schools, some of which have risen in general estimation into the rank of what are called PUBLIC SCHOOLS.

Schools, Infant. These schools, for the education of children up to the age of five or six years, are said to owe their origin, as a public institution, to Mr. Owen of New Lanark. In the report of the Education Commission of 1863 they are divided into private or dame schools, and public infant schools, 'which frequently form a department of an ordinary day school.' In fact, it will be found that in the stage which popular education has now reached, infant classes, in Sunday and day schools, have, to a certain extent, superseded special schools for infants. In the best infant schools (say the commissioners) 'much is done, and even much is taught.' 'The real education of the children is carried on for the most part in the direct intercourse with the teacher: the children seated in the gallery, and the teacher standing before them, and constantly "performing," as it were, with such varieties of position, attitude, tone, gesture, method, and bearing, as shall best warm their minds to the

reception of the new truths that are to be conveyed to them.' In 1854, Mr. Horace Mann (*Census of Education*) estimated the total number of scholars in Great Britain under the age of six at 400,000; which, at the rate of increase observed in scholars generally, would now reach 600,000 or 700,000.

Schools, National. After public attention had been drawn to the advantages of Dr. Bell's system of mutual instruction in schools, chiefly through the activity of Mr. Lancaster, two societies were formed in England for carrying it into general operation. The British and Foreign School Society was founded by Dissenters in 1805; the National Society, by members of the Establishment, a few years later. The instruction of the former, in religion, is confined to those points in which all are agreed; that of the latter is founded on the liturgy and catechism of the established church. The schools of these two societies are now extensively spread over the face of the kingdom. The education given by them is nearly gratuitous, but certain small payments are in some cases exacted. Mr. Hill, in his work on the state of education in England, estimated the children attending schools of the former union at 60,000 or 80,000, and those of the National schools at about 170,000. Reading, writing, and arithmetic, with religious knowledge according to the principles of the respective institutions, form the amount of education generally given; but in some schools geography, and even the elements of geometry, are taught; and attempts have been made to add instruction in various branches of manual industry. Each society has a model school and establishment for training teachers. That of the British and Foreign is in the Borough Road: the principal one of the National in the Sanctuary, Westminster; but it has others in different places.

Schools, Normal. Schools for the education of persons intended to become schoolmasters, teachers, or professors in any line. Normal schools form a regular part of the establishments for education in many Continental states, especially in Germany. The normal school of Paris was suppressed in 1821, but revived a few years afterwards. In England there are many establishments, known as Training Colleges, for the purpose of educating masters for Primary Schools.

Schools, Primary. A phrase popularly applied to all schools devoted to the elementary education of the poorer classes: of which Sunday schools and day schools (National, British and Foreign, &c.) are classes. Mr. Mann (*Educational Census of* 1854) excludes mere infant schools from this category. In Great Britain, the number of primary schools, inspected by government officers, had increased from 4,237 in 1856 to 8,438 in 1865; the average number of children in attendance, from 571,000 to 1,300,000. The public expenditure for education grants from 1839 to 1862 amounted in round numbers to 6,700,000*l.*: of which about 4,000,000*l.* had been expended on schools in connection with the Church of England; 600,000*l.* in schools of the British and Foreign Society; 400,000*l.* of the Church of Scotland; 300,000*l.* of the Free Church of Scotland; 300,000*l.* Wesleyan; 200,000*l.* Roman Catholic. The expenditure in 1865 was 636,810*l.*

Schools, Public. This is a name of not quite definite application, by which a certain number of schools are designated, conferring a classical education, having on the average a large number of boys, and frequented by the children of persons of rank and wealth. The principal are: 1. The three colleges, two of royal and one of private foundation—Eton, Winchester, and Westminster. 2. Some or all of the great metropolitan endowed schools, such as Charter House, St. Paul's, Merchant Tailors'. Accordingly, these six foundations, together with those of Harrow, Rugby, and Shrewsbury, were specified as public schools in the commission directed in 1861 to 'enquire into their administration and management, and the system and course of studies respectively pursued therein,' &c.; the report of which body, with its evidence, furnishes now by far the most valuable guide to a knowledge of the several subjects.

Of these schools, the majority have a considerable *foundation*, i.e. a certain number of boys are educated there on what may be termed the collegiate principle, living together, and with their expenses to a great extent defrayed by the foundation. But at those of private establishment the foundationers are mere day scholars. At Eton, there were, in 1861, 61 foundationers (or *collegians*) and 722 non-foundationers (*oppidans*); at Winchester, 69 and 128 respectively; at Westminster, 40 and 96.

The great purpose of these schools at the present day is, therefore, the education of the sons of members of the higher classes of society, not on the foundations. And this is notoriously expensive. Generally speaking, it may be said that boys remain at these schools from the age of twelve or thirteen to eighteen or nineteen. The ordinary expense of a boy at Eton is stated by the commissioners at 144*l.* per annum, besides *extras* amounting in most cases to 20*l.* or 30*l.* more, 'exclusive of clothes, pocket money, and other pocket expenses.' The expense of Harrow is probably equal, that of the others somewhat less.

The governing body (in the royal foundations) is 'the college,' consisting of a head and fellows or canons; in most of the others, in a body of 'governors,' usually self-elected and incorporated. These appoint, and can dismiss, the head master, who usually appoints the assistant or under masters.

The course of study pursued in these great schools is still mainly classical. Mathematics, modern languages, and other branches of knowledge, have been partially introduced, and under circumstances so varying as to render a summary impossible. The extension

of the *course* is very strongly recommended by the commissioners.

The discipline of these schools varies greatly, under the administration of successive masters. With regard to one point in it which has attracted much attention, *fagging*, the commissioners report that some menial offices, too commonly assigned to *fags*, ought in their opinion to be allotted to servants; but, on the whole, and with allowance for the exception produced by occasional tyranny and mismanagement, they think that it 'is not degrading to the juniors, and has no injurious effect upon the character of the seniors.'

The public schools had in former times a closer connection with the universities than they now have, or are likely to retain. Eton (i.e. the college) monopolised the foundation of King's College, Cambridge; Winchester, that of New College, Oxford; other schools had numerous scholarships and fellowships appropriated to their pupils. But the changes of late years in the universities themselves have materially affected these privileges.

The royal commission, 1862, for enquiring into the conduct of the public schools extends to those above mentioned, with the exception of Christ's Hospital.

Schools, Scottish Parochial. In the reign of James IV. (1494), the Scottish legislature enacted that all barons and substantial freeholders should send their children to school from the age of six to nine years, and afterwards to the academical institutions. But it was not until 1615 that the foundations of the present system were laid by an Act *empowering* the bishops, together with a majority of the landlords, or *heritors*, to establish schools in every parish. In 1696, by another statute, the establishment of such schools was *directed*. The appointment of the schoolmaster was vested in the heritors and minister; the burden of the expense of erecting the school and a dwelling-house for the master, and paying to the latter a salary of not less than 5*l*. 11*s*. 1*d*. nor more than 11*l*. 2*s*. 2*d*. per annum, being supported by the former. The general supervision of the schools was intrusted to the presbyteries in which they were situated. Besides the salary (which has been raised to a maximum of 34*l*. 4*s*. 4½*d*., and a minimum of 25*l*. 13*s*. 3⅜*d*.), the master is supported by trifling fees from the scholars. Reading, writing, and arithmetic, some of the branches of practical mathematics in ordinary use, and even a slight amount of classical learning, have been usually taught in these parish schools. Such is a short outline of the system, of the results of which, in the general education and morality of the poorer classes, Scotland has been so justly proud.

Schools, Sunday. These schools were first set on foot by Mr. Robert Raikes of Gloucester. According to Mr. Hill, in his work on national education, the number of children frequenting Sunday schools varied, when he wrote, from 800,000 to 900,000. The average length of a Sunday-school education he estimates at four years; the education given is almost uniformly confined to reading alone; but many Sunday schools appear to have evening schools connected with them, open two or three times a week, in which writing and arithmetic are taught.

Schooner. A small sharp-built vessel, with two masts of considerable length and rake, with small top-masts, and fore and aft sails. A square-rigged schooner carries square topsail and top-gallant sails; but a fore-and-aft schooner has fore-and-aft sails on both masts, with occasionally a square topsail on the fore-mast. Schooners have sometimes, though rarely, three masts. It is one of the swiftest rigs.

Schorl (Swed. skorl, *brittle*). The name given to black opaque varieties of Tourmaline. It is a silicate of various bases, chiefly alumina, soda, lime, magnesia, and iron. It occurs in vitreous prismatic crystals; it is brittle and has much lustre, and becomes electric by heat and friction. It is found in Cornwall, at Boscawen Cliffs, Botallack Mine, St. Michael's Mount, and generally on the borders of the granite of that county; also in the granite of Chudleigh in Devonshire and off Portsoy in Banffshire; Stillorgen, co. Dublin, &c.

Schreibersite. A mineral of a steel-grey colour often found in meteoric stones. It is chiefly composed of phosphorus, nickel, and iron; and was named after V. Schreibers, of Vienna.

Schrötterite. A hydrated silicate of alumina found at Dollinger Mountain, near Freienstein in Styria, in amorphous greenish or yellowish masses; also in Alabama at the falls of Little River, Cherokee county, in brownish translucent incrustations, which resemble gum arabic when broken. Named after J. S. Schrötter.

Schulzite. An antimonial sulphide of lead found in Spain, at Meredo in Gallicia, in nodules in Galena.

Schweinfurth Green. A compound of arsenious acid, acetic acid, and oxide of copper, in appearance much resembling Scheele's Green.

Sciadopitys (Gr. σκιάς, σκιάδος, *a canopy*, and πίτυς, *a pine-tree*). The Umbrella Pine, a genus of Coniferous trees peculiar to Japan, and recently introduced into our gardens. It has been cultivated from time immemorial by the Japanese around their temples. The trunk is erect, from 100 to 150 feet high, the habit pyramidal, the branches verticillate; the leaves are linear and sessile, from thirty to forty growing together at the end of the branches. It is a singular and valuable evergreen tree, of a highly ornamental character.

Sciænoids (Gr. σκίαινα). The name of a family of Acanthopterygian fishes, of which the genus *Sciæna* is the type. This family is nearly allied to the Percoids; but both the vomer and palatine bones are without teeth; the bones of the head are generally cavernous, and the muzzle more or less enlarged and obtuse.

Sciatic Artery. One of the large branches of the anterior trunk of the internal iliac artery is so called. It supplies the deep-seated muscles at the back of the hip.

Sciatic Nerve. The largest nervous cord in the body. It supplies nearly the whole of the integuments of the leg, the muscles of the back of the thigh, and those of the leg and foot.

Sciatic Stay (possibly a corruption of *Asiatic*). A rope passing between the main and fore tops and sustaining a pulley used in loading or unloading the hold of a ship. The pulley can move upon the sciatic stay.

Sciatica (Gr. ἰσχίον, *the socket of the thigh joint*). A rheumatic affection of the hip joint. [Rheumatism.]

Science (Lat. scientia). In its most comprehensive sense, this term is applied to the knowledge of many, methodically digested and arranged so as to become attainable by one. The knowledge of reasons and their conclusions constitutes *abstract*, that of causes and effects and of the laws of nature *natural* science. The term *science* is, however, more particularly used in contradistinction to *art* and *literature*. As distinguished from the former, a *science* is 'a body of truths, the common principles of which are supposed to be known and separated, so that the individual truths, even though some or all may be clear in themselves, have a guarantee that they could have been discovered and known, either with certainty or with such probability as the subject admits of, by other means than their own evidence.' [Art.] As distinguished from *literature*, science is applied to any branch of knowledge which is made the subject of investigation with a view to discover and apply first principles. [Literature.] The various sciences will be found under their particular heads.

For the distinction of deductive and inductive science, see Aristotelian Philosophy, Baconian Philosophy, Socratic Philosophy; and for the canons of inductive science, see Logic.

Scilla (Lat.; Gr. σκίλλα). A genus of ornamental bulbous plants of the order *Liliaceæ*, and related to hyacinths. They are chiefly interesting as flower-garden plants, some of them being amongst the most lovely of early spring flowers, and one or two being natives of our own country. The common name for the genus is Squill, but the medicinal squill, the most important plant of this affinity, is now referred to a distinct genus. [Urginea.]

Scillitin. The bitter principle of the Squill (the bulb of the *Urginea Scilla*, formerly *maritima*), to which its medical properties of an expectorant and diuretic are referable. It is a white substance, of a resinous appearance.

Scimetar. A curved sword, much used by Oriental nations, and frequently found in Europe in the latter half of the fifteenth century.

Scincoids. A family of Saurian reptiles, of which the genus *Scincus* is the type. They have short feet, a non-extensible tongue; the body and tail are covered with equal scales, like tiles; they have no impressed lateral line, and the toes are margined.

Scink. [Skink.]

Scintilla Juris (Lat. *a spark of law*). A possibility of legal seisin which has been supposed by some learned real property lawyers to exist in some cases in the grantee under a conveyance of hand, for the purpose of enabling springing or contingent uses to arise. [Use.] This highly technical doctrine was never generally admitted in theory, or much regarded in practice; it has, however, been recently thought proper to abolish it formally by stat. 23 & 24 Vict. c. 38, sec. 7.

Scintillation (Lat. scintillatio, from scintilla, *a spark*). In Astronomy, the term applied to the *twinkling* or tremulous motion of the light of the larger fixed stars; by which they appear as if the rays of light coming from them were not continuous, but produced by particles succeeding each other at intervals with a sort of vibratory movement. The planets, excepting when very near the horizon, have not this twinkling appearance; and they are thus readily distinguished from stars of the first magnitude. It arises from the extreme smallness of the apparent diameters of the fixed stars, and the unequal refracting power of our atmosphere at the different temperatures and pressures of the layers of air through which a star is seen. This unequal refraction causes the apparent displacement of the star to a small extent. The twinkling of the stars is therefore greatest when they are near the horizon, and when the air is disturbed by currents of unequal temperature. The stars near the zenith rarely twinkle, and when seen from the summit of a lofty mountain the phenomenon is also, for obvious reasons, greatly diminished.

Sciography (Gr. σκιαγραφία, from σκία, *a shadow*, and γράφω). In Painting, &c., the art of casting and delineating shadows with truth, and upon mathematical principles.

Sciolto (Ital.). In Music, a term which, applied to counterpoint, signifies that it is free and not constrained by general rules. When applied to notes, it signifies that they are not tied together 

Scion (Fr.). In Horticulture, the first young shoot produced during the year by a tree; or, more commonly, a part of a branch prepared for the purpose of being grafted upon some other tree.

Scioptic Ball or **Scioptric Ball** (Gr. σκία, *shadow*, and ὄπτομαι, *I see*). A name sometimes given to a mechanical contrivance, used in the *camera obscura*, for the purpose of giving motion to a lens in every direction.

Scire Facias (Lat.). In Law, a judicial writ, which lies in various cases, as for instance to call on a party to show cause to the court whence it issues why letters patent should not be repealed.

Scissel (Lat. scissilis, *that may be rent* or *cloven*). The clippings of various metals produced in several mechanical operations concerned in their manufacture. The slips or plates of metal out of which circular blanks have been cut for the purpose of coinage are called *scissel* at the Mint.

Scitamineæ (a name extracted from Lat. scitamenta, *dainties*). A group of monocotyledonous plants, formerly recognised, and including the Musas, the Gingers, and the Marantas of modern times. It is almost entirely tropical and includes many plants of considerable size, and all remarkable among monocotyledons for their leaves, which are often large and have pinnate or diverging veins, and for their unsymmetrical flowers, their perfect stamens being always reduced to five or fewer, whilst the perianth divisions are of the normal number, six. The whole group comprises three tribes or orders—*Musaceæ*, with more perfect anthers than one; *Zingiberaceæ*, with only one perfect two-celled anther; and *Marantaceæ*, with only one perfect one-celled anther—the other stamens (if present) being always converted into barren and mostly petal-like staminodia.

Sciurinea (Gr. σκίουρος, *a squirrel*). The Squirrel tribe. The name of a family of Rodents, of which the genus *Sciurus* is the type. They are distinguished by their very narrow lower incisors, and by their long and bushy tail. They have four toes before, and five behind. The thumb of the fore foot is sometimes marked by a tubercle. The molars are tuberculated.

Scleranthaceæ (Scleranthus, one of the genera). A small uninteresting order of perigynous Exogens belonging to the Ficoidal alliance of Lindley's arrangement. They are known by their apetalous flowers, and by their single solitary carpel, over which the tubular calyx becomes hardened. They are few in number, and occur on barren ground in Europe, Asia, and North America.

Sclerodermi (Gr. σκληρόδερμος, *hard-skinned*). A name given by Cuvier to a family of Plectognathic fishes, comprehending those which have the skin covered with hard scales.

Sclerogen (Gr. σκληρός, *hard*, and γεννάω, *I produce*). In Botany, the ligneous or bony matter deposited in the cells of plants.

Scleroskeleton (Gr. σκληρός, and σκελετόν, *a dried body*). Those bones which are developed in tendons, ligaments, and aponeuroses, e.g. the *tentorium* in the cat, the *temporal fascia* in the turtle, the *leaders of the leg-muscles* in the turkey, the *nuchal ligament* in the mole, and certain tendons of the abdominal muscles of the Kangaroo which, so ossified, are called the *marsupial bones*.

Sclerotica or **Sclerotic Membrane** (Gr. σκληρός, *hard*). The outer tunic of the eye is so called. In man it is opaque, and forms the posterior five-sixths of the globe of the eye. It is white externally, brown internally, and is much thicker behind than in front. In many birds, and some fossil reptiles, it developes a circular series of bony plates around the eyeball. [EYE.]

Scolex (Gr. σκώληξ, *a worm*). The first or primitive segment of a tapeworm (*Tænia*) is so called, which originates itself from a *Cysticercus*, and developes *proglottides*, who in their turn become free, and independent from the *parent* organism.

Scolezite or **Skolezite** (Gr. σκώληξ). A hydrated silicate of alumina and lime, which occurs in prismatic and acicular crystals, and also massive with a fibrous and radiating structure. It is colourless, snow-white, greyish, yellowish, and reddish, and transparent to translucent at the edges. It is found in Staffa, Iceland, Greenland, the Faroe Islands, the Tyrol, &c.

When heated before the blowpipe, it shrinks up with wormlike contortions before fusing; whence the name.

Scolopacidæ (Gr. σκόλοπαξ, *a woodcock*). The Snipe tribe. The name of a family of wading birds, of which the genus *Scolopax* is the type. The snipes proper have a straight beak, the nasal furrows extending to near its point, which is a little furrowed externally, so as to extend beyond the lower mandible. The point is soft and very sensible.

Scolopendra (Gr.). The generic name of the Centipedes.

Scolopendrium (Gr. σκολόπενδρα). The generic name of the Hart's-tongue, one of our common British species of ferns.

Scomberoids (Gr. σκόμβρος). The Mackerel tribe. The name of the family of fishes of which the genus *Scomber* is the type. They are characterised by having a smooth body covered with small scales, and a very powerful tail and caudal fin.

Sconce (Dan. skands; Ger. schanze, *a bastion*). An obsolete word, formerly applied to a small fort for the defence of a pass, river, or other place. (Scott, *Legend of Montrose*, ch. xi. &c.)

Scopa (Lat. perhaps *a thin branch*; but it is seldom found in the singular number: the plural, scopæ, is *a broom* or *besom*). In Mammalogy, a fasciculus of long flaccid hairs, which may grow from any limited part of the body or extremities.

Scoparin. The crystalline, neutral, diuretic principle of the *Sarothamnus scoparius* or Common Broom.

Scopipeds (Lat. scopæ, *a broom*, and pes, *a foot*). The name of a tribe of Melliferous insects, including those which have the tarsi of the posterior feet furnished with a brush of hairs.

Scops (Gr. σκώψ). The horned owl, of which more than one species is found in Great Britain.

Scoriæ (Lat.; Gr. σκωρία, *refuse*). Volcanic ashes of a reddish brown and black colour, the cinders and slags of a particular kind of lava. In appearance volcanic scoriæ greatly resemble the slags of an iron furnace, and

are in fact stony or imperfectly glassy products obtained under circumstances not very different in the great laboratory of nature.

Scorodite (Gr. σκόροδον, *garlic*, in allusion to its smell when heated). A hydrated arseniate of iron, formerly found in Cornwall on ferruginous quartz, and in pale bluish-green radiating groups, lining the interior of cavities.

Scorpio (Lat.). In Astronomy, the eighth sign of the zodiac, and one of the ancient zodiacal constellations. When this constellation rises, Orion sets; hence the mythological fable of the death of ORION, who perished by the sting of a scorpion. [CONSTELLATION.]

Scorpioid (Gr. σκορπιοειδής, *scorpion like*). In Botany, that form of inflorescence in which the main axis is curved in a circinate manner like the tail of a scorpion, as in the Forget-me-not.

Scorpion (Lat. scorpio; Gr. σκορπιός). A well-known Arachnidan Articulate, in which no spinnerets exist at the extremity of the body, their place being supplied by a venomous apparatus. They are common in the tropics, where they frequently attain a gigantic size. As in the case of most similar forms, the sting can be cured by the outward application of ammonia.

Scorza or **Skorza.** The common name in Transylvania for the granular Epidote, which occurs in the form of sand near Muska, on the banks of the river Aranyos.

Scorzonera (Span. escorza, *a serpent*). A genus of *Compositæ*, which includes a valuable esculent species. This plant, the *S. hispanica* of botanists, and the Scorzonera or Vipers' grass of gardeners, is a native of Spain, but is cultivated in this country for its roots, which are sold in the markets. They are of very easy cultivation, growing vigorously in good ground, and bearing our hardest winters without injury. The root is nearly the shape of a carrot, but smaller and dark-coloured, while internally it is pure white. The taste is sweet and agreeable, something like that of the roots of certain umbelliferous plants or the common hazel-nut. Its effects on the digestive organs are to increase the flow of gastric juice and bile, and as it acts as a deobstruent on the alimentary organs generally, it is slightly aperient. Its antibilious power is scarcely, if at all, inferior to that of dandelion. These good effects, however, cannot be insured unless the vegetable is properly cooked, as its medicinal quality may be quickly destroyed. It should be cut as little as possible, and washed instead of scraped, for the abundant milky juice, on which its salutary properties depend, escapes when it is bruised. After boiling for about twenty or twenty-five minutes or till it is quite soft (rather more salt being added to the water than usual in cooking vegetables), it is to be taken out and peeled, as the dark skin then comes off as readily as that of a boiled potato. When fresh from the garden, a quarter of an hour may be sufficient. It is of some importance to the invalid to know this, because after it has become quite soft all further boiling is injurious to its medicinal quality and soon destroys it; but when it has lain out of the ground for a long time and become hardened, it may require twice the time boiling, the rule then being to boil it till it is soft. It is usually eaten in the same way as asparagus, which is the preferable mode for the invalid. As it is one of the most agreeable of vegetables as regards flavour, it undoubtedly deserves to be much more cultivated.

Scot (Sax. sceat, *part* or *portion*, in the sense of contribution). This old word has passed into various ordinary expressions, such as 'scot-free,' &c., and at one time found its way into the Italian language (Dante, *Purgatorio*). In English Law, it is still retained in the phrase 'inhabitants paying scot and lot,' which has long been held to mean paying parochial rates, and constituted one of the old rights of voting in various boroughs existing before the Reform Act.

Scotch Bonnets. The Champignon, *Marasmius* (or *Agaricus*) *Oreades*, one of the Fungi which give rise to fairy rings.

Scotch Pebble. A name given to the Agates found in Scotland, where they occur abundantly, as irregularly shaped nodules, in the amygdaloid of Dunbar and the hill of Kinnoul near Perth.

Scotches (perhaps connected with A.-Sax. sceadan; Gr. σχίζη, *a cleft piece of wood*). Wedges of wood placed under a wheel to stop its rolling.

Scoter. A name of the black duck, or Black Diver (*Anas nigra*, Linn.), now the type of the subgenus *Oidemia*, Fleming.

Scotia (Gr.). In Architecture, the name of a hollow moulding, chiefly used between the tori in the bases of columns. It takes its name from the shadow formed by it, which seems to envelop it in darkness.

Scotists. An old scholastic sect, followers of Duns Scotus, 'the subtle doctor,' one of the leading champions of Realism in the thirteenth century. He held that the *universal* existed not *in posse* only, but *in actu*; not depending in anywise on the conditions of the understanding, but presented to it as an outward reality. In this respect his realism differs from that of his predecessor, Thomas Aquinas. [SCHOLASTIC PHILOSOPHY.]

Scotodinia (Gr. from σκότος, *darkness*, and δίνη, *a whirling*). Giddiness with imperfect vision. A symptom occasionally observed in dyspepsia, especially in that of gouty persons.

Scouring Drops. The essential oils of lemon and of bergamotte are sold under this name, for the purpose of removing grease stains from silk dresses. They are generally adulterated with oil of turpentine.

Screeds (etym. uncertain). In Architecture, wooden rules for running mouldings. Also the extreme guides on the margins of walls and ceilings for floating to, by the aid of the rules. They are always necessary for running a cornice when the ceiling is not floated.

Screen (Fr. écran). In Architecture, a partition usually wrought with rich tracery. Such partitions were commonly erected in churches as supports of the rood-loft [ROOD], and to rail off altars, chapels, and tombs from the rest of the building.

Screw (Dutch schroef, Ger. schraube). In Mechanics, one of the six mechanical powers, consisting of a spiral ridge or groove, winding round a cylinder, so as to cut every line on the surface parallel to the axis at the same angle. The screw may be formed either on the outside or inside of the cylinder; in the former case, it is called the *exterior* or *male* screw; in the latter, the *interior* or *female* screw. The action of the screw resembles that of the wedge, or inclined plane; but as the cylinder has always a handle attached to it, the screw is in reality a compound of the inclined plane and lever; and if the direction of the power be parallel to the base of the cylinder, and perpendicular to its radius, equilibrium is produced when the power is to the resistance or pressure as the interval between the adjacent threads is to the circumference described by the point to which the power is applied. Hence the mechanical advantage afforded by the screw is proportional jointly to the fineness of the threads and the length of the lever or handle. It is to be observed, however, that by diminishing the distance between the threads, we diminish also the strength of the screw; and hence there is obviously a limit to the increase of power. But the action is greatly increased by means of the contrivance called a *differential screw*, or, from the name of its inventor, *Hunter's screw*, which consists in the combination of two screws of unequal fineness of thread, one of which unwinds while the other winds, and the effective progression at each revolution is only equal to the difference of the pitches of the two screws, which may be made as small as we please, and consequently the screw may be made as powerful as we please, since the power is always corresponding to the slowness. In Hunter's screw we obtain the power due to a very fine pitch without its weakness.

The *endless screw* consists of a screw combined with a wheel and axle in such a manner that the threads of the screw work into the teeth fixed on the periphery of the wheel. Suppose the power applied to the handle of the screw, and the weight attached to the axle of the wheel, then there will be equilibrium when the power is to the weight as the distance between the threads multiplied by the radius of the axle is to the circumference described by the power multiplied by the radius of the wheel.

The *water screw*, or *screw of Archimedes*, is formed by winding a tube or channel round a cylinder in the form of a screw. If the machine, thus constructed, be placed obliquely, so as to make with the vertical an angle equal to that which the spiral makes with the lines parallel to the axis of the cylinder, there will be in each convolution of the spiral a part parallel to the horizon. If any body, then, be placed within the spiral at this part, it will remain at rest; and if the screw be turned the body will ascend, because the part of the screw behind it becomes more inclined than the part before it, and it is consequently urged forward. This simple but ingenious contrivance is usually employed for the purpose of raising water to a small height, but it may be employed to raise any substance that can pass within the tube.

The *micrometer screw* is a contrivance adapted to astronomical or optical instruments, for the purpose of measuring angles with great exactness. The very great space through which the lever of the screw passes in comparison of that which is described by the cylinder in the direction of its length, renders the screw of immense use in subdividing space into minute parts.

As a mechanical power, the screw has innumerable applications; but it is employed with most convenience in cases in which a very great pressure is required to be exerted within a small space, and without intermission. A common purpose to which the screw is applied is that of connecting pieces of wood or metal together either in the form of screw nails or in that of bolts and nuts. In both cases the friction of the thread of the screw is sufficient to prevent the screw from unwinding when forcibly tightened up, and the screw is of invaluable use in the arts for attaching objects firmly together. If there be much jar or vibration in the objects thus connected, the screws will be liable to work loose; and in the screws used to attach the floats of paddle-wheels to the arms, and in the various attachments of locomotives, the nuts are liable to shake loose. In some cases a second nut, called a *jam nut*, is introduced above the common nut to prevent unwinding, and this is usually done in the bolts of paddle wheels; but besides this, the thread should be slightly nicked with a chisel to prevent the nut from working back. In locomotives *split pins*, as they are termed, are introduced running through holes in the point of the bolts; and these pins, after being pushed through the holes provided for their reception, expand sideways, and cannot fall out, while their presence prevents the nuts from unscrewing without clipping them off.

Screw Jack. An instrument employed for lifting heavy weights and consisting essentially of a screw so disposed as to enable the pressure it exerts to be conveniently applied. A similar instrument, called a *dumb craft*, is sometimes used instead of a screw jack into which wheels and pinions are introduced which protrude a ram by means either of a rack or screw; and by the point of this ram the pressure is communicated.

Screw Pine. The common name for the species of *Pandanus*. [PANDANACEÆ.]

Screw Propeller. An instrument for the propulsion of vessels, consisting of two or more

twisted blades, like the vanes of a windmill, set on an axis running parallel with the keel, and revolving beneath the water at the stern. The screw propeller is driven by a steam engine situated within the vessel, and by its revolution in the water it carries the vessel forward, as a cork-screw is drawn forward when penetrating a cork, or a bolt when turned round in a stationary nut. The water in which the vessel floats forms the nut of the screw propeller; and thus when the propeller is turned round, the vessel is screwed on. To enable the water to act as the nut of the screw, the thread traced in the water requires to be very much deeper than if it were traced in metal or wood, and the pressing surface of the screw must be large, to prevent the thread from being stripped or broken by the reacting force. Accordingly, screw propellers are made with a small central body and deep thread; they are also made as large in diameter as possible, reaching, usually, from the keel to near the surface of the water. In the length of the screw only a very short piece, usually about one sixth of a convolution, is employed.

History of the Screw Propeller.—The screw propeller is probably as old as the windmill; and a windmill of the construction now usually employed is represented in the 77th proposition of Hero's *Spiritalia*, a work written 130 years before the Christian era. In China screw propellers are said to have been employed from a very early date as an arrangement for sculling vessels; and in fact a screw is a continuous sculling machine, in which the necessity of reciprocating motion is superseded by giving a complete revolution to the propelling blade. Captain Basil Hall, in his account of his voyage to Loo Choo, states that the Coreans scull their ships instead of rowing them; and, from what he saw of the operation, he is inclined to give the preference to that mode of propulsion. The galleys of the Greeks and Romans were also propelled by an action of the oars more nearly resembling sculling than rowing, as was first pointed out by Robert Hooke in 1684; and Hooke also showed that this mode of action would be exceedingly efficient. In a work entitled *Philosophical Collections*, printed for Richard Chiswell, printer to the Royal Society, 1681, there is a paper by Hooke on Horizontal Windmills, containing various suggestions of great originality and importance. Hooke says that he does not consider horizontal windmills to be as efficient as vertical windmills: but if they are in any case employed, it will be advisable, he says, to make them on a certain construction, of which he gives a representation, and which is almost identical in its main features with the most improved species of feathering paddle wheel now employed in steam ships. Hooke adds, that wheels of this kind may be set to work advantageously as water wheels in a river where no dam can be made, as may also the common vertical windmill with twisted arms. In this cursory suggestion we have the germ both of the screw propeller and the feathering paddle wheel. Robertson Buchanian admits having taken the idea of his feathering wheel from the mechanism of orreries which was invented by Hooke; and the same considerations which make the screw and feathering wheel eligible instruments when driven by the water equally hold when the water is driven by them.

On October 14, 1683, Hooke showed to the Royal Society an instrument which he had invented for measuring the velocity of the wind. It consisted of four vanes, like the vanes of a windmill, set upon an axis, the vanes being so constructed that they could be set at any angle that was desired. On November 28, in the same year, Hooke showed to the Royal Society an instrument which he had shown to some of the members twenty years before, for measuring the way of a ship through the water. The prime mover of this instrument was a screw turned by the water, and the instrument not merely took cognisance of the progress of the vessel through the water, but also of the lee way. The plan of making gearing in steps, as is now usually done in such screw vessels as make use of gearing, is also an invention of Hooke's. Wheels made upon this principle are divided in the direction of their breadth into a number of parallel wheels which are set a little in advance of one another, so that the teeth of each do not come in the same line. The benefit of this practice is that the teeth, though necessarily very thick to give adequate strength, work as smoothly as if they were thin and small, or as if the space between the teeth were only a fractional part of its actual amount.

In the *Recueil de Machines approuvées par l'Académie, depuis* 1727 *jusqu'au* 1731, there is a machine described, which was invented by M. du Quet, for dragging up barges against a current in a river by the aid of a screw driven by the water; and by the screw thus driven a rope, dragging the barges, is to be wound up. This screw, which is a helical blade wound upon an axis, is only partially immerged in the water, and it would be a much less effectual instrument than the screw of a windmill form previously recommended by Hooke. In Bouguer's *Traité du Navire*, published in Paris in 1746, an arrangement of revolving oars, resembling the vanes of a windmill, is mentioned as having been proposed for the propulsion of vessels; but this expedient, it is stated, had not been found to possess sufficient force. In 1752, Daniel Bernoulli obtained the prize offered by the French Academy of Sciences for the best project for impelling vessels without the aid of the wind. Bernoulli's apparatus consisted of an iron axle 14 feet long and two inches thick, set upon each side of the vessel beneath the water. Each axle was to carry eight wheels, six feet diameter, set at equal distances from one another, and each wheel was to have eight arms or spokes, to the extremity of each of which a sheet-iron plane 16 inches square, and inclined so as to form an

angle of 60° with the axle or keel of the vessel, was to be affixed. Bernoulli's plan appears to have been contrived to meet Bouguer's objection, and it would probably answer for towing, but the revolution of such a large number of wheels in the water would in all cases of considerable speed occasion a serious loss of power from friction and other analogous causes.

In Emerson's *Principles of Mechanics*, published in 1754, we have an explanation of the mode of constructing screws with an expanding or increasing pitch. Emerson describes an arrangement of screw set vertically in a well or stationary cylinder, as an instrument for rendering available a fall of water in giving motion to mills. The water is admitted at the top of the cylinder and escapes at its base, and in its descent it turns round the screw by which the cylinder is filled up. Emerson explains, that at the top of the cylinder the blade of the screw must have very little inclination with the axis, but at the bottom of the cylinder the blade of the screw must have a considerable inclination with the axis. Blades set in a conical pit or vessel, and driven round by the gravity of water, have long been in use in France, under the name of Danaïdes, or *roues à poires*; and in some cases the blades were merely plane surfaces suitably inclined, while in other cases they were spiral or screw-formed. Instruments of this kind are described by Belidor in his *Architecture Hydraulique*.

In 1768, a work on the Archimedean screw was published at Paris by M. Paucton; and it is suggested that a ptérophore, composed of the circumvolution of the thread of a screw round a cylinder, should be placed on each side of a vessel to propel her through the water, or one only may be used at the fore part. These screws, it is stated, may be either wholly or partially immersed. In 1776, a submarine vessel was invented by D. Bushnell, an American, which was to be raised upward or sunk downward in the water by means of an inclined blade or oar affixed to the top and operating in the manner of a screw, and forced forward or backward in the water by another similar blade affixed to the bow. This vessel was to carry a powder magazine, which was to be screwed to the bottom of an enemy's ship to blow her up. It was the original of Fulton's torpedo.

In 1784, Joseph Bramah, of London, engineer, obtained a patent for propelling vessels by means of a wheel with inclined fans or wings, similar to the fly of a smoke-jack or the vertical sails of a windmill. This wheel was to be fixed to an axis passing out at the stern of the vessel, and was to revolve beneath the water with a stuffing box or proper packing surrounding the shaft, where it pierces the vessel, to prevent the water from entering. In 1794, William Lyttleton, a merchant of London, obtained a patent for an instrument which he called an 'aquatic propeller,' and which consisted of a single convolution of a three threaded screw. The thread of a screw is the projecting part of it, and a screw may have one, two, three, or any other number of threads. A string wound round a cylinder represents the thread of a screw; and if one string only be wound round it, the screw will be a screw of one thread; if two strings be wound round it, so as equally to divide the space, the screw will be a screw of two threads; and so of any number. If, instead of a string, a thin ribbon of iron be wound edgeways round the cylinder, and be soldered thereto, then a slice cut off the end of this screw will have two projecting arms or portions of this ribbon, if the screw be one of two threads; three projecting arms, if of three threads; and so of any other number. In any screw propeller, therefore, the number of threads is the same as the number of arms. The pitch of the screw is the distance from one thread of the screw to the next thread measured on the axis, supposing the screw to be continued through a whole convolution. A spiral stair is virtually a screw; and the pitch is the vertical distance from any one step of the stair to the step immediately overhead.

In 1799, Edward Shorter, of London, mechanic, obtained a patent for propelling vessels, and among the expedients which he employed is one termed a 'perpetual sculling machine,' consisting of a screw immerged in the water at the stern of the vessel. The shaft, which gives motion to the screw, passes through the stern of the vessel above the level of the water, and is armed at its extremity with one of Hooke's universal joints, from whence a pole extends obliquely into the water with the screw attached to its extremity. The end of the pole is prevented from sinking too deeply in the water by a buoy which supports it at the proper elevation, and guy ropes are applied, by means of which the pole and screw may be moved to the one side or the other, so that the vessel may be steered, or assisted in her steerage, thereby. Between 1800 and 1836 various arrangements of screw propellers were proposed by Dallery, Stevens, O'Reilly, James, Trevithick, Boswell, Millington, Scott, Whytock, Delisle, Bourdon, Dollman, Perkins, Brown, Tredgold, Maceroni, Cummerow, Smith, Church, Copley, Ovinel, Peltier, Salichon, Poole, Woodcroft, Sauvage, Emerson, Burke, Theal, Smith, and Fitzpatrick. The forms of these screws are very various, but in most cases they consist of helical blades, like the vanes of a windmill, revolving beneath the water at the stern, or of a helical feather coiled round an axis, in the manner of an Archimedean screw. In some cases the pitch of the screw is intended to be uniform, and in other cases increasing, the uniform pitch being a straight line wound upon a cylinder, and the increasing pitch being a curved line wound upon a cylinder, or a straight line wound upon a cone or spire. Bourdon, in 1824, formed his screw with an increasing pitch, and placed it in the dead wood of the vessel. Tredgold, in his work upon the Steam Engine, published in 1827, recommended that screws should be made with an increasing pitch. Peltier, in 1830, proposed to make his

screw with an increasing pitch, and Woodcroft proposed the same thing in 1832. Marestier, in 1824, in a work published by direction of the French government, giving an account of steam navigation in America, described various arrangements of screw propellers which had been tried in that country, but none of those expedients had come into practical operation. Lyttleton in 1794, Shorter in 1802, Stevens in 1804, Bourdon in 1824, and several others at different times, had practically tried the effect of propelling vessels by means of a screw. But these experiments led to no useful result, and in 1836 there was no vessel propelled by a screw in existence. In that year patents for propelling vessels by a screw were taken out by F. P. Smith and Captain John Ericsson; and to these two persons the successful introduction of the screw as a propeller must be attributed. Ericsson, not meeting in this country with the encouragement that he expected, went to America, where he soon after constructed the war steamer Princeton, and in 1862 he designed the Monitor class of screw turret vessels. Smith, as soon as his early trials had demonstrated the efficacy of the screw as a propeller, built the Archimedes, and soon afterwards his propeller was applied to the war steamer Rattler. It has subsequently been applied to most of the sea going steamers, whether constructed for purposes of war or of commerce in this and other countries, and is now the species of propeller in general use, although paddles are still used for river vessels and also for the conveyance of certain mails which require to be carried in all weathers at a high rate of speed.

It would swell these remarks beyond the limits to which they must be restricted, to attempt any enumeration of the various modifications in the form of the screw, and in the mode of its application, which have been made or proposed since its practical introduction as an available propeller. In this country vessels are, for the most part, fitted with screws of a uniform pitch formed with either two or three arms, but sometimes with four arms. Griffith's screw with shovel-formed blades and a central ball is much used in the navy, where a form of screw with four blades, of which the leading half of each blade has a less pitch than the following half, has also been in some cases employed; but has been discarded. Mangin's screw, which consists substantially of two double-bladed screws with very narrow blades set immediately behind one another on the screw shaft, has also been employed in some cases with good results, the space between the screws allowing the water to pass; and as the column of water in which the screw revolves is less put into rotation, there is less shake at the stern.

In Smith's earlier experiments upon the screw propeller he employed a single-threaded screw of two convolutions, such as that represented in fig. 1. During one of his trials, however, the screw having come in contact with some object in the water, about half of it was broken away, and the vessel was found in consequence to realise a higher speed than before. The Archimedes was originally fitted with a single-threaded screw of one convolution, such as that represented in fig. 2.; and it was with a screw

Fig. 1.

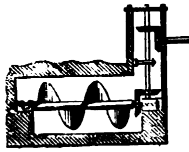
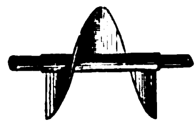


Fig. 2.



of this kind that the efficiency of the screw as a propeller was originally demonstrated. She was subsequently fitted with a double-threaded screw of half a convolution, which gave the same amount of propelling surface, and diminished the uneasy motion at the stern. This screw is represented in fig. 3. The Rattler was fitted with a screw of this kind, but its length was subsequently reduced to one-sixth of a convolution, which made its length just one-third of its original length, and the best results were obtained with this proportion. This amended screw of the Rattler is shown in perspective in fig. 4.

Fig. 3.

Fig. 4.

Ericsson, in his original form of propeller, employed two wheels armed with helical blades and revolving in opposite directions. The object of this arrangement was to neutralise any tendency which one wheel might have to turn the vessel from her appointed course. The second wheel however was soon discarded, as it was found that it was not required. Fig. 5 represents Ericsson's original arrangement of

Fig. 5.

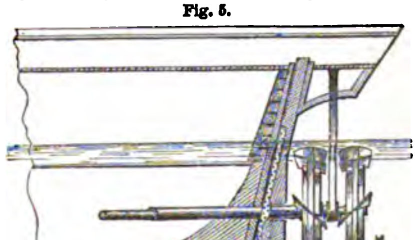


Fig. 6.

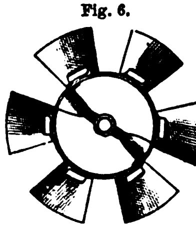
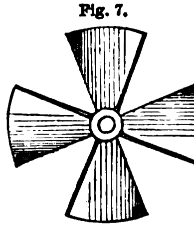


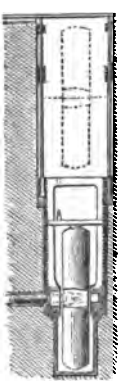
Fig. 7.



the screw propeller, and fig. 6 is the propeller of the Princeton, which was subsequently superseded by a four-bladed screw of the form shown in fig. 7.

Description of the mode of applying the Screw Propeller.—In the most approved method of introducing the screw propeller into a vessel, the screw is set in a hole or opening in the dead wood behind the stern post, and before the rudder post. It is sometimes hung upon a short shaft, which is carried by a metal frame with a rack on each side, and in these racks endless screws work, which, being put into revolution, raise the frame, lifting the propeller out of the water, so as to enable the screw to be repaired if required, or a new one to be introduced without putting the vessel into dock. Before, however, the frame can be raised, the shaft, which, passing through the ship, communicates with the engine, has to be pulled on end, so as to disengage it from the boss of the short shaft, which supports the screw. A vacant space is left between the end of the shaft which communicates with the engine, and the end of the shaft which communicates with the screw, so as to enable the shaft communicating with the screw to be drawn on end without disturbing the other shaft; and a short pipe fixed to the one shaft, but sliding on the other, is so applied that, notwithstanding the end play, the force of torsion will be communicated from the one shaft to the other. Figs. 8 and 9 represent the screw propeller and the apparatus for raising it out of the water, as applied in H.M. steam frigate Ajax. By a reference to these figures, the configuration of the screw usually employed for the service of the navy, and the mode of raising it out of the water, will be readily understood. A catch represented as engaging the centre of the screw is put down only when the screw requires to be raised out of the water, and its use is to retain the blades in a vertical position during that operation.

Fig. 8.



This method, however, of constructing the screw connections so that the screw might be raised out of the water when the vessel was under sail alone, though at one time widely adopted in the navy, never found much favour in the merchant service, and latterly in the navy also it has been discarded. The method described of raising the screw was available only when the screw was formed with two blades, and in most cases it is found advisable to keep the screw in water at all times, but to let little steam into the engines when the wind is fair, thus economising the coal nearly as much as if the screw were to be disused altogether during those periods.

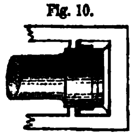
Fig. 9.

The screw shaft, at the point where it passes through the stern of the vessel, is kept tight by means of a stuffing box, consisting of a long pipe fitted tightly into the hull of the vessel. Through this pipe the screw shaft passes, and the space between the shaft and the pipe is kept tight by means of a plaited rope of soft hemp forced tightly into a recess provided for the purpose by means of screws. It is very desirable that the shaft should fit so accurately into this pipe as to be exempt from all side play, which, if it exists, will have the effect of communicating a disagreeable motion to the stern of the vessel. In wooden vessels the pipe should be made of brass; and it has been found advantageous to cover with brass that part of the shaft that revolves within the pipe, so as to obviate corrosion from the sea-water and also to enable strips of lignum vitæ to be introduced to constitute a bearing for the shaft. Wooden bearings or bushes are found to be better than metal ones in the case of all shafts or bearings working in water. But the metallic surface in contact with the wood should be brass and not iron when salt water is the lubricant, else the iron will be roughened by corrosion, and will then rasp the wood rapidly away. In all cases the extremity of the vessel in advance of the screw should be brought to as fine a line as possible, and the hole in the dead wood in which the screw revolves should be considerably larger than the screw itself. The screw in its revolution carries with it a coating of water, and if this coating be partially stripped off at every revolution from the too near proximity of the stern part of the vessel, a shock will be communicated at every revolution, from the impact of the water against the side of the dead wood, and a part of the engine power will be also dissipated without effect.

Modes of receiving the Thrust of the Screw.—As the screw by its revolution is forced forward in the water, carrying the vessel with it, the screw shaft, it is clear, must have to sustain a forward thrust, and it is this thrust, in fact, which propels the vessel. The severity of this forward thrust, combined with the velocity of rotation which the screw shaft must maintain, was the occasion, in the earlier screw vessels, of considerable inconvenience, in consequence of the friction produced; and several cases have occurred where the end of the shaft became white hot, and actually welded itself to the steel plate against which it pressed, although a stream of water was all the while running upon the surfaces in contact. Various expedients have since that time been proposed for receiving the thrust, of which one was to let the end of the shaft enter, in the manner of a piston, a tight cylinder of oil, so that it would be against a liquid only that the end of the shaft would press. Another expedient was to place a large collar upon the shaft, which would press against a number of balls or small rollers resembling the rollers of a swivelling bridge. Neither of these plans, however, has come into practical use; but one of two other modes is now generally followed. Either the thrust is received

upon a number of collars, which are recessed into a suitable bearing, or it is received upon a series of discs applied to the end of the shaft, and resting in a cistern of oil, as represented in fig. 10. The cistern is usually cast upon the base plate or some other solid part of the engine, and its end is sufficiently strong to bear the thrust of the screw. Interposed, however, between the end of the cistern and the end of the shaft are two, three, or more discs of metal, usually about two inches thick, and of the same diameter as the shaft itself. A bolt passes through their centres to keep them in a line, but they are each free to revolve upon this bolt; and where the shaft passes out of the cistern a collar of leather is applied, to prevent the oil from escaping. It will be obvious from such an arrangement that if the end of the shaft, where it presses upon the discs, begins to heat from undue friction, it will revolve with somewhat more difficulty, and will consequently carry the first disc round with it. The rubbing surfaces, therefore, are no longer the end of the shaft and the first disc, but the first disc and the second disc. In fact, the rubbing surface, instead of being confined to one disc, is distributed over several. Those surfaces, which begin to heat, and consequently to stick, will cease to rub, and thus they will speedily become cool again, and their efficiency will be soon restored. The more usual mode of receiving the thrust of the screw, however, is by a collar bearing, the collars being turned out of the solid shaft and the encircling bearing being generally of brass, but sometimes of wood. Bearing surfaces of wood for receiving the thrust were first introduced by Mr. Alexander Gray, engineer of the steamer Himalaya. The brass bearing of the collars being very much worn, Mr. Gray introduced rings of lignum vitæ between the collars on the shaft and the collars of the brass, these rings having been each introduced in four pieces and while the vessel was at sea.

Fig. 10.



Best Proportions of Screw.—For mercantile purposes screws with three blades are, on the whole, to be preferred. The diameter of the screw should be as large as it can be conveniently got, and when the area of the screw's disc—that is, the area of the circle described by the extremity of the arms of the screw—has one square foot of area for every $2\frac{1}{2}$ square feet in the area of the immerged midship section of the vessel, a very efficient performance is obtained. The pitch of the screw should be equal to the diameter of the screw, or a little more, and the length of the screw fore and aft should be that answering to one-sixth of a convolution. Thus, in the case of a screw twelve feet in diameter, the pitch would be twelve or fourteen feet, and the length of the screw measured along the axis would be about two feet.

Best Forms of Screw.—Screws are commonly made with a uniform pitch, and with the blades standing at right angles with the axis. A slightly progressive increase in the pitch, however, say to the extent of 5 per cent., appears to be advisable—i. e. the pitch of the screw at its leading end should be 5 per cent. less than at its following end. The pitch at the centre should also be 10 per cent. less than the pitch at the circumference, for the centre should merely screw through the water without seeking to produce any reacting force, which, from the great obliquity of the blades at the centre, could not be done with advantage. Finally, the blades of the screw should be bent a little astern, so as to produce in the particles of water which they force backwards a tendency to converge to a point. This tendency will balance the divergent tendency produced by the centrifugal action of the screw in its revolution, and the two forces, by balancing one another, will cause the water to be projected backwards from the screw in a cylindrical column. With the ordinary screw the water projected backwards assumes the figure of the frustum of a cone, and some portion of the power is thus lost.

Griffith's form of screw, as already explained, is formed with a large central ball and with blades narrower at the point than near the boss, so that each blade has a shovel form, and this species of screw is now much used. Perforated screws, corrugated screws, and many other kinds of screws have been tested since the earlier editions of this work appeared, without, however, the manifestation of any qualities which encouraged their adoption. In Rigg's screw the screw may be of the usual kind; but a series of radial blades, like another screw having twice the number of blades possessed by the screw itself, is fixed stationary behind the screw on the rudder post. These blades, set at the opposite angle from that of the blades of the screw itself, are pressed upon by the revolving column of water which the screw puts into rotation; and this revolving column, by pressing obliquely on the backs of the fixed blades, assists in forcing the ship forward. The rudder post may be made to constitute two of these fixed blades by twisting the portions of it beneath and above the shaft in opposite directions.

Positive and negative Slip of the Screw.—When a vessel is propelled by oars, paddles, or any other instrument which acts upon the water, it is obvious, that since the water is not a solid body which can resist without disturbance the application of force, there will be a certain amount of recession in the water, or, in other words, the water will be moved to a certain extent backwards, while the vessel is forced to a certain extent forwards. This backward movement of the water is what is termed *Slip*, and in its results it is analogous to the loss of power and speed which a locomotive experiences when the wheels slip upon the rails. This slip exists in the case of the screw as well as in the case of the paddle or other

species of propeller; and when the engines of a steam vessel are set in motion while the vessel is at anchor or moored in a river, the whole power of the engines is wasted in slip, or in moving the water without moving the vessel. The ordinary amount of slip in paddle vessels is about one-third of the whole distance travelled, or, in other words, the vessel would go one-third faster with the same number of revolutions if the wheels geared into an iron rack instead of gearing into water. In well-constructed screw vessels the slip is only ten per cent., or, in other words, the vessel would only go one-tenth faster with the same number of revolutions if the screw worked in an iron nut instead of working in water. Since, therefore, all the power expended in producing slip is lost, and since there is less slip with the screw than the paddle, there is an apparent superiority in the screw from this cause. In some screw vessels, however, the apparent slip is nothing at all, and in others it is less than nothing, or, in other words, the vessel is propelled through the water by the screw alone at a greater velocity than if the screw worked in a solid nut with the same number of revolutions. In the early history of the screw propeller, this apparent paradox provoked much incredulity, but the phenomenon is now understood, and is not difficult of explanation.

When a vessel passes through the water, the friction of the bottom and the sides puts a column of water in motion which proceeds in the direction of the vessel. Sea-weeds and other light objects adhering to a vessel have been observed to stand out straight from her side when the vessel was moving through the water with a considerable velocity, thus making it clear that a film of water must be moving with the vessel. The vacuity also which the motion of the vessel through the water tends to produce at the stern causes a flow of water towards the stern in order to fill it up. It follows, therefore, that a vessel, in passing through the water, puts in motion a stream or current which follows in her track; and that this is no hypothetical supposition is proved by the fact that a boat will often follow a vessel without being towed by a rope, and that when a slow steamer gets into a swift one's wake the slow steamer will not fall into the distance, but will be towed by the current which the leading steamer creates. Now, in a screw vessel the screw works in this current; and if from the form of the stern or other causes the current runs at a considerable velocity, and if from the large dimensions of the screw or otherwise the actual slip of the screw be small, then it will often follow that the slip of the screw will *appear* to be less than nothing, or negative, if the comparison be made not with the current, but with the stationary water at the ship's side. The screw must at all times have slip *relatively with the water in which its works*; but if that water is itself in motion, it is not surprising that the vessel should travel through a greater distance than what answers to the pitch and revolutions of the screw, any more than that a paddle vessel in descending a river with a strong current should pass through a greater distance than what answers to the diameter and revolutions of the wheel, if the distance travelled be measured on the river bank. A log placed where the screw revolves will always show that the screw advances with a greater velocity than the vessel as measured at that point, or, in other words, that the screw passes through the current with a greater velocity than the vessel passes through the current, though of course the speed of the vessel and of the current together may be greater than the speed of the screw alone.

Further, the screw acts upon water moving inwards towards the stern, while the hydrostatic and hydraulic heads of water are not the same. The moving water will be higher than the stationary, that the two may be in equilibrium; and the arrested momentum of the two converging streams where they meet will raise the level of the water at the stern and force the vessel on by hydrostatic pressure. The same action will ensue if the screw be made with a very fine pitch, for the centrifugal force of the adhering water will in such case raise a wave against the stern; the velocity of rotation of the screw being greater, the smaller the pitch. Fine pitches, blunt sterns, the action of sails, and many arms in the screw, unless the pitch be at the same time made very coarse, all conduce to the creation of negative slip, which is caused mainly or wholly by the interference of the vessel and not by the action of the screw itself. Mr. Rankine, Mr. Froude, Mr. Reed, and others, have endeavoured to explain the phenomena of negative slip, which, however, is mainly imputable to the causes enumerated above.

Measure of the Thrust upon the Screw Shaft, and Amount of Power lost by Slip.—In some vessels a dynamometer has been applied to the end of the screw shaft, and it has thus become possible to measure accurately the amount of forward pressure exerted by the screw. In the Rattler, a vessel of 888 tons burden, this pressure amounted, on an average, to about four tons. This pressure, multiplied by the space passed through by the vessel per minute, and divided by 33,000, will manifestly give the force in actual horse power that is instrumental in the propulsion of the vessel, and the power thus computed amounts, on an average, to about half or two-thirds the power developed in the cylinders. It hence appears that, in screw vessels such as the Rattler, from one-third to one-half of the engine power is wasted in slip and in the friction or other resistances caused by the revolution of the screw in the water. With the paddle wheel the loss from these causes is nearly the same, and the screw and paddle consequently produce about the same speed by the application of the same amount of power.

Relative Efficiency of the Screw and Paddles.—To determine the relative efficiency of the screw and paddle as a propeller, two vessels, the Rattler and the Alecto, were constructed of about the same power, 200 horses, and of nearly the same size and form; but the Rattler was a screw vessel, and the Alecto a paddle vessel. The Rattler, it was found, had, in nearly all cases, somewhat the advantage in point of speed, but the engines of the Rattler also exerted somewhat more power. Subsequently two other vessels, the Niger and Basilisk, were constructed of 1,072 tons, and 400 horse power, the Niger being a screw vessel, and the Basilisk a paddle vessel, and the following were the results obtained:—In deep immersions the screw vessel had an advantage of 1¼ per cent. over the paddle vessel, but with medium immersions the paddle vessel had an advantage of 1¾ per cent. over the screw vessel, and in light immersions the paddle vessel had an advantage of 4¾ per cent. over the screw vessel. The slip of the screw was 24 per cent. Upon the whole, therefore, the screw seems to have somewhat the advantage when the vessel is deep, and the paddle seems to have somewhat the advantage when the vessel is at a light or medium immersion.

Screw Vessels not adapted to go Head to Wind.—The experiments with the Rattler and Alecto established one important fact in connection with screw vessels, viz. that they are ill adapted to advance against a head wind. For, although both vessels attained the same speed of 4 knots against a strong head wind, yet, in the case of the Alecto, this performance was attained with a velocity of the engine of 12 strokes per minute; whereas, in the Rattler, it was only attained with a velocity of the engine of 22 strokes per minute. It follows, therefore, that a screw vessel in proceeding head to wind will require 1·8 times, or nearly twice the quantity of fuel to do the same amount of work. The screw, in fact, revolves at nearly the same velocity whether the wind is adverse or favourable, or whether the vessel is lying at anchor; and this is a serious defect in the case of vessels intended to encounter adverse winds. In the case of vessels, however, which use the screw only as a resource in calms, or as an auxiliary to the sails, this disadvantage will not be experienced, since such vessels have no pretensions to the capability of proceeding in direct opposition to a strong head wind, and the evil will be diminished if the screw be immersed deeply in the water, as may best be done when twin screws set in the quarters are employed.

Paddle and Screw Vessels tied Stern to Stern.—In all cases where screw and paddle vessels of equal power and size have been tied stern to stern, the screw vessel has preponderated, and towed the paddle vessel so soon as the engines were set on. When the Rattler and Alecto were tied together in this manner, the Alecto's engines were set on first, and she was allowed to tow the Rattler at the rate of 2 knots an hour. The Rattler's engines were then set on. In five minutes the two vessels became completely stationary. The Rattler than began to move ahead, and towed the Alecto against the whole force of her engines, at the rate of 2·8 knots per hour. In like manner the Niger towed the Basilisk astern, in opposition to the force of her engines, at the rate of 1·1 knots per hour. The natural inference from this experiment would be that the screw is more suitable for towing than the paddle; yet this inference is not confirmed by experiment. For, when the Niger and Basilisk were each set to tow the other alternately, in the usual manner in which a steamer tows a ship, it was found that the Niger towed the Basilisk at a speed of 5·63 knots, with 593·9 horse power, and that the Basilisk towed the Niger at the rate of 6 knots, with 572·3 horse power. The paddle vessel, therefore, accomplished in towing the largest speed with the least power. It has also been found that when a paddle and screw vessel set stern to stern push one another instead of pulling one another, the paddle vessel preponderates, whereas, if they pull, the screw vessel preponderates. These circumstances seem to show that the power of a screw vessel to tow a paddle vessel astern, when the two are tied together, does not arise from any superior tractive efficacy of the screw itself, but is due to the centrifugal action of the screw, which raises the level of the water at the stern, so that the vessel gravitates down an inclined plane.

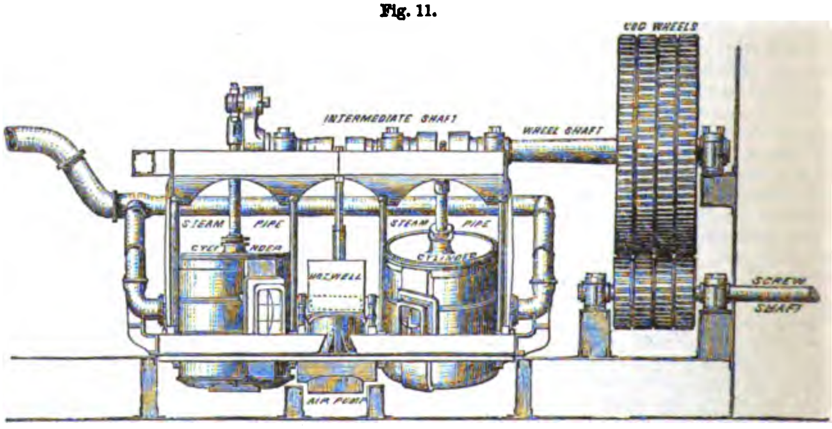
Cause of the serrated Outline of the Dynamometer Diagram.—In those screw vessels which have had a dynamometer applied to the end of the shaft the thrust of the screw was made to act upon a spring, and a pencil in connexion with the shaft marked a line upon a revolving cylinder, which line was either high up on the cylinder, or low down, as the thrust of the screw increased or diminished. The line thus traced, instead of being tolerably uniform and straight, was found to be serrated, like the teeth of a saw; and, on further investigation, it was discovered that every time the screw, in its revolution, brought the blades into the vertical position, and therefore into a line with the stern post, at that moment the thrust was increased. This phenomenon appears to be due to the circumstance of the water immediately behind the stern post being carried forward with nearly the same velocity as the vessel itself; and when the screw comes into that dead water, as it is termed, it is no longer a reaction answering to the *difference* of speed of the screw and vessel that it has to encounter, but a reaction answering to nearly the *whole* speed of the vessel. If such a reaction had to be encountered through the whole revolution of the screw, the velocity of its rotation would be necessarily diminished until the reacting pressure produced was balanced by the pressure on the pistons of the engine. But the momentum of the machinery and of

the screw itself momentarily carries up the thrust to a higher point than that due to the pressure on the pistons. If a screw vessel be reversed until she attains full speed astern, and be then suddenly changed to full speed ahead, it will be found that a dynamometer diagram, taken at that point at which the vessel is stationary in the water, from the effort to overcome her own momentum, will have a straight, and not a serrated line.

Importance of making the Stern of Screw Vessels very sharp and fine.—The preceding remarks will have very clearly indicated the importance of making screw vessels as sharp as possible at the stern; but the following facts may be stated in corrobation of the propriety of such a configuration: In 1846 the Dwarf, a screw steam vessel, with a fine run, was filled out in the stern by the application of three successive layers of planking, so as to alter the shape to that of a vessel with a full run. Prior to the alteration the speed of the vessel was 9·1 knots per hour, the engines making 32 revolutions per minute. The effect of the filling was to reduce the speed to 3·25 knots per hour, with a speed of the engine of 24 revolutions per minute. One layer of filling was then taken off, and the speed rose to 5·75 knots per hour, the engines making 26·5 revolutions per minute. When the whole of the filling was removed the speed rose to 9 knots, as before. Care was of course taken in this experiment to bring the filling into conformity with the lines of the vessel, so that there should be no roughness or abruptness to aggravate the evils of a full run. Again, the Sharpshooter and Rifleman were sister vessels of 486 tons, and 200 horse power, but the Rifleman was made with a full run, and the Sharpshooter with a fine run. The speed of the Rifleman was found on trial to be 7·9 knots, and of the Sharpshooter 9·9 knots. The Minx and Teazer were sister vessels of about 300 tons and 100 horse power, but the Teazer was made with a full run, and the Minx with a fine run. The speed of the Teazer was found to be 6·3 knots, and of the Minx 7·8 knots. The sterns of both the Rifleman and Teazer were sharpened subsequently to these trials, and the 100 horse engines of the Teazer were at the same time put into the Rifleman, while new engines of 40 horse power were put into the Teazer. Both vessels went faster than before. The Rifleman, when sharpened at the stern, attained a speed of 8 knots with engines of 100 horse power, whereas she had before only attained a speed of 7·8 knots with engines of 200 horse power. The Teazer when sharpened at the stern, attained a speed of 7·685 knots with engines of 40 horse power, whereas she had before only attained a speed of 6·3 knots with engines of 100 horse power. The engines of the Teazer, when transferred to the Rifleman drove that vessel nearly 2 knots an hour faster than they had previously driven the smaller vessel, an amelioration consequent altogether upon the sharpened form of the stern.

Engines for driving the Screw.—It will be obvious, on looking to the pitch of an ordinary screw, and the speed with which the vessel passes through the water, that the screw must revolve with a considerable velocity. For example, if a vessel be driven 10 miles an hour, or 880 feet per minute, by a screw of 12 feet pitch, then the screw must make somewhere more than the twelfth part of 880, or 73 revolutions in the minute. This is a much higher speed than marine engines have been heretofore accustomed to travel at, and two methods of obtaining the necessary velocity of rotation have been adopted. In the one, the construction and speed of the ordinary engine have been retained without material

Fig. 11.

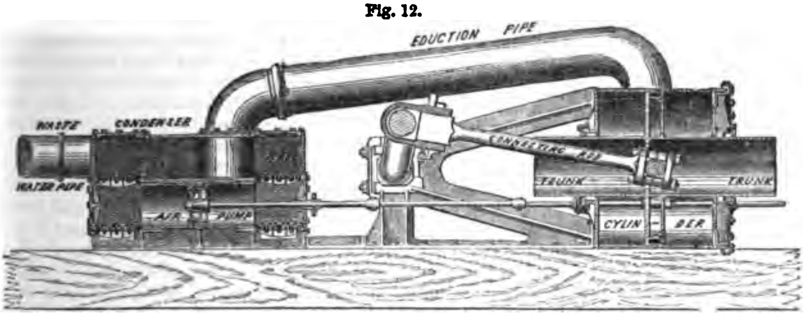


alteration, and the required velocity of revolution has been given to the screw shaft by means of intervening gearing. In the other case, a new arrangement of engine has been introduced which is capable of moving with a much greater velocity than ordinary engines,

and the engine and screw shaft are directly connected with one another. Fig. 11 represents a pair of geared screw engines, being the engines constructed by Messrs. John Penn and Son for the Great Britain. These engines are on the oscillating principle, which Messrs. Penn have rendered so celebrated, and they are almost identical in construction with the paddle engines made by Messrs. Penn for the Sphinx and other vessels. The Great Britain is of 3,500 tons burthen, and her displacement, at 16 feet draught of water, is 2,970 tons. The diameter of cylinder is 82½ inches, length of stroke 6 feet, nominal power 500 horses, diameter of screw 15½ feet, pitch of screw 19 feet, length of screw 3 feet 2 inches. The screw has three arms or blades. The multiple of the gearing is 3 to 1, and there are 17½ square feet of heating surface in the boiler for each nominal horse power of the engine. The crank shaft, being put in motion by the engine, carries round the great cog wheel or aggregation of cog wheels affixed to its extremity, and these wheels acting on suitable pinions on the screw shaft cause the screw to make three revolutions for every revolution performed by the engine.

Fig. 12 is a representation of a pair of

Fig. 12.



direct-action screw engines, being the engines constructed by Messrs. John Penn and Son for H.M.'s screw frigates Arrogant and Encounter. Here the cylinders lie in a horizontal position, and are traversed through the centre by a pipe or trunk, upon which the piston is cast. The central trunk is circular, and it projects through both the top and bottom of the cylinder, the points of penetration being made tight by suitable packing. One end of the connecting rod is attached to the centre of the trunk, while the other end engages the crank, which turns round the screw shaft. The air-pump, which also lies in a horizontal position, is double-acting, and is situated within the condenser. A large pipe, called the eduction pipe, leads the steam from the cylinder to the condenser, where it is condensed by a jet of cold water, and the hot water thence resulting is ejected by the air-pump through the waste water pipe, and passes overboard. In the figure only one cylinder and one air-pump are represented, but it will be understood that there are two cylinders and two air-pumps. The valves by which the water is admitted to the air-pump from the condenser and passes again from the air-pump into the hot well and waste pipe, consist of several discs of Indian-rubber, kept down by a central bolt so as to cover radial slits or orifices in a perforated plate. These valves are found to operate without noise or shock, notwithstanding the high speed at which the engine must work in order to give motion to the screw without intervening gearing. The diameter of the cylinder in the Arrogant and Encounter is 60 inches, and the diameter of the trunk 24 inches, which, being deducted, leaves an available area of piston equal to that of a piston 55 inches in diameter. In the Arrogant the length of stroke is 3 feet, and the Encounter is 2 feet 3 inches. The nominal power of both engines is 360 horse. The diameter of the screw of the Arrogant is 15 feet 6 inches, and the diameter of the screw of the Encounter is 12 feet. The pitch of both is 15 feet, and the length 2 feet 6 inches. The Arrogant is a vessel of 1,872 tons burden, and the Encounter of 953 tons. Both the engines and boilers are kept below the water-line, so as to be out of the reach of shot. Engines similar to this, but of greater power, have been constructed by Messrs. Penn for the Warrior, Black Prince, Minotaur, Achilles, Bellerophon, Northumberland, &c. But the use of a trunk which passes into the steam and then into the atmosphere at every stroke, is not conducive to economy of fuel.

The forms of engine, both geared and direct-acting, for giving motion to the screw, are too numerous to be here described. But in most war vessels the cylinders are placed upon their sides, so as to keep the engines below the water-line. In merchant vessels a form of engine like the land beam engine, with the cylinder at the one end of a beam and the connecting rod at the other—the connecting rod extending downwards from the end of the beam to give motion to the crank—is frequently employed. In other cases the cylinder is inverted, and a connecting rod proceeds from the end of the piston rod to turn the crank, the end of the piston rod being, of course, steadied by suitable guides.

In the edition of this work published in 1852, it was pointed out that in horizontal engines, like those of Messrs. Penn and Son, it would be better to place the trunk in the air-pump instead of in the cylinder; and a form of engine of this kind was subsequently patented by Messrs. Robert Napier and Sons, of Glasgow, and was introduced by them into several vessels. The overhead, or forge hammer engines, as they are sometimes called, constructed by Messrs. Caird & Co. for the Bremen, Hansa, and other transatlantic vessels, and by Messrs. Napier and Son for the Pereire and Ville de Paris, have been highly efficient and economical. But that species of engine is not adapted for ships of war, as it rises above the water-line; and the form of horizontal engine originally designed by Mr. Holm in 1844 for the Amphion, and introduced into the merchant service by Mr. Bourne in 1853, is now the form of engine most generally adopted for all purposes whether of war or commerce by marine engineers. Mr. Bourne, in 1853, first introduced the plan of balancing the momentum of marine engines by counterweights attached to the crank; and soon afterwards Mr. Penn introduced similar counterweights into the engines of the Himalaya, and they have since become general. The Amphion form of engine is virtually a steeple engine, as it is called, laid on its side. The cylinder is horizontal and two piston rods, one above the shaft on one side of the crank, and the other below the shaft on the other side of the crank, proceed to engage a cross head which moves horizontally in guides on the opposite side of the crank. From this cross head a return connecting rod proceeds to the crank, and heavy weights are attached to the side of the crank which is opposite to the crank pin, to balance the momentum of the piston and its connections. This form of engine is now adopted by Messrs. Maudslay, Ravenhill, Napier, Day, and other leading marine engineers.

Screw Vessels with Auxiliary Power.—We have already stated that screw vessels, intended to go head to wind and to contend against head seas, are not so efficient as paddle vessels, inasmuch as they require more coal to do the same work. Under the conjoint influence of sails and steam, however, they are under most circumstances as efficient, and, if deeply laden, are more efficient. A screw vessel being divested of paddle boxes, partakes more of the character of a sailing ship; nevertheless, from the experiments with the Niger and Basilisk, it does not appear that a screw vessel is more efficient under sails than a paddle vessel, although such a result might naturally be expected. The advantages incident, therefore, to the use of screw vessels with auxiliary power do not result from any superiority of the screw as a propeller, nor from the increased facilities which it presents for the application of sails, but are to be ascribed to the large employment in screw vessels of wind power, which costs nothing, instead of steam power, which costs much, and also to the maintenance of lower rates of speed than are thought necessary in paddle vessels. The screw, indeed, is a less cumbrous propeller than the paddle, and, in consequence of the high speed of engine which it permits, a very considerable engine power will go into a small compass.

Screw Vessels with Auxiliary Power.—The use of the screw as an auxiliary propeller to sailing ships was at one time regarded as among its most promising applications, and vessels were accordingly made with hoisting screws or with feathering screws, to enable the screw to be raised out of the water, or the blades to be set in a line with the keel when the vessel was under sail alone. Practically, however, vessels fitted with screws and engines have maintained them in constant action, and have contented themselves with working the steam very expansively in the cylinders in fair winds, so as under those circumstances to save the coal. The liability of derangement of all kinds of hoisting and feathering apparatus has been a serious discouragement to the perpetuation of such plans, and although screw vessels are still made of small power as well as of large power it cannot be said that any auxiliary screw vessels are now employed in the sense of the screw being put wholly out of action in fair winds. The want of some propelling apparatus of small power which would be able to drive forward a sailing ship in calms is still much felt, especially in the case of vessels which require to cross the line. But a screw placed beneath the water at the stern is not the most eligible expedient for that purpose, as it would require to be large and cumbrous to obviate a wasteful amount of slip; and there is a settled objection in the case of sailing vessels to the introduction of machinery into the hold, and to the perforation of the vessel by shafts and pipes for the sake of a benefit which may only be realised for a few days during the whole voyage. Mechanism for this kind of auxiliary propulsion should be situated upon the deck, and the boiler should be combined with the cooking and distilling apparatus, so as to be as generally useful as possible. The most convenient apparatus would probably be a large and broad vertical oar set on each side of the vessel and moved slowly outward and inward with a sculling action like the action employed in propelling the ancient galleys. The oar would require to be feathered at every stroke, which would be done by bending the arm or by placing more of the blade on one side of the vertical axis than upon the other. For coasting purposes, screw vessels of moderate power have not only superseded paddle steamers but also sailing ships to a considerable extent, as they are found on the whole to carry more cheaply.

Twin Screw Vessels.—Many screw vessels are now constructed with a screw projecting through the vessel at each quarter, instead of employing a single screw at the stern, and this plan has the advantage that the necessary propelling area may be got at a lower

depth, while by turning one screw ahead and the other astern the vessel may be turned as on a pivot without any aid from the rudder. In some cases, the body of the vessel is split near the centre, and each division terminates in a stern of its own, with its own screw and rudder. In other cases, the screw shaft protrudes through the oblique run of the ship on each side, and its outer end is supported by a suitable wrought iron frame, while the rudder is set in the usual place. For war purposes, double screws present many advantages. They afford more power of rapid evolution; by being more sunk in the water, they are more out of the reach of shot, and the vessel will not be disabled if the rudder or one of the screws should be damaged or destroyed. The Kalamazoo class of American Monitors is built with double screws 15 feet diameter. Each vessel carries two turrets 26 feet diameter, and 15 inches thick of iron, and the side armour is of iron 14 inches thick.

Conditions to be observed in the Construction of Screw Vessels.—The whole of the superior eligibility of screw vessels for the conveyance of merchandise, whether compared with paddle vessels or sailing ships, is not due to the action of the screw itself or to the use of steam power. Much, probably most, of it arises from the superior form of a vessel which has been simultaneously introduced, and by which the sails have been rendered much more efficient than heretofore in urging the vessel through the water. The main conditions necessary to the satisfactory performance of screw vessels lie in making the form of the vessel sharp and fine, in applying a large amount of sail power, and in keeping the screw well immersed in the water. Screw vessels should be broad at the water line, so as to enable them to bear the pressure of a large amount of sail; and the sails should be as flat as possible, and be laced to the spars, so as to enable the vessel to go as near as possible to the wind. The rigging of all vessels is still in a most defective state. It is without any provision whatever for using up the power of the wind in an effectual manner, and a large proportion of that power is consequently lost. Under suitable arrangements, vessels would be able to sail directly against the wind, instead of having to tack, as is at present the practice; and there is every reason to believe that, before many years, expedients for this purpose, and for obtaining from a given force of wind and area of sail a much larger propelling effect, will be applied.

For further information respecting the screw propeller see a *Treatise on the Screw Propeller*, by John Bourne, C.E., third edition, 1866, from which the engravings and most of the information given in this article have been extracted. See also Admiral Paris's report on the naval architecture in the Exhibition of 1862 (*Rapport sur l'Art Naval en* 1862).

Screw Surface. [HELICOID.]

Scribe (Lat. scriba). The copyists, and at the same time the interpreters of the law, in the later periods of the Jewish history, were called Scribes. In the New Testament, we find them generally mentioned in connection with the Pharisees, with the leaders of which sect, together with the High Priests, they appear to have constituted the Sanhedrim. In addition to their other functions, they were concerned in education, and in reading and expounding the law to classes of pupils in the outer courts of the temple. Some ancient writers conceive the scribes to have formed peculiar sects by themselves; but there is no authority for this opinion.

Scribing (Lat. scribo, *I write or scratch*). In Architecture, fitting the edge of a board to another board in the same plane as the edge. In joiner's work, it is the fitting one piece of wood to another so that their fibres may be respectively at right angles.

Script (Lat. scriptus, *written*). In Printing, a kind of type cast in imitation of writing. The French call it *Anglaise*. There is no character of type on which so much labour has been bestowed as on this. The old scripts were cast on square shanks, the ascending and descending letters being *kerned*, and therefore liable to be broken off. In 1815, Messrs. Firmin Didot & Sons introduced a new script cut with great freedom and cast on a rhomboidal shank, with triangular blocks having a corresponding angle on one side, and the other two sides forming a right angle, with which to *justify* the beginnings and ends of lines. Messrs. Laurent and Deberney, French artists, about thirty years since introduced a new square-bodied script called *Américain*, so beautifully cut and managed, that the effect produced when worked is excellent. The *kern*, instead of being unsupported, is protected by the shank of the letter, having two angles thrown out at the head of the two opposite corners of the body, so as to give support to both ascenders and descenders; the opposite angles of the letters are cast with a corresponding slope to receive the kerned letters without their incurring any danger of riding upon each other.

Scriptures, Holy. The name commonly used to designate the writings of the Old and New Testaments, which are comprised in the CANON. [BIBLE.]

Scrivener (Span. escribano, from Lat. scribo, *I write*). Money scriveners, in old English usage, were persons who received money to place it out at interest, and supplied others, who wished to borrow, with money on security, a class of business now undertaken, in different departments, by bankers, money-brokers, and solicitors. The last regular scrivener is said to have been a person of the name of Jack Ellis, a contemporary of Dr. Johnson, mentioned in Boswell's *Life*. The city company of scriveners remains to attest the ancient importance of the business.

Scrobicularia (Lat. scrobiculus, dim. of scrobs, *a ditch*). A genus of Dimyarian Acephalous mollusca, allied to *Psammobia*.

Scrofula. This disease was termed by the Greeks αι χοιράδες, *swollen* or *indurated glands of the neck*, to which it was said that the pig (χοῖρος) is especially subject. Hence the Latin term *scrofula* has been traced to scrofa, *a sow*; but the origin is in either case very dubious, the Greek word being akin, perhaps, to χέῤῥος, *hard*, and the Latin to scrupus and rupes, *a stone* or *pebble*.

It is now regarded as the result of a general disorder to which the name *tuberculosis* is given. The blood is diseased, and according to the age of the patient different organs are liable to become attacked by tubercular deposit. In early infancy this deposit gives rise to water on the brain. In early manhood pulmonary consumption is the result, while in the intermediate period of life we find mesenteric disease appearing. The popular use of the word *scrofula* consists more especially in its application to tuberculosis in children. It is most common among delicate children with fair complexions, and those disposed to rickets. It is rare in warm climates, and seems to be favoured by cold and variable countries. It is promoted by everything that debilitates; and when its exciting causes are by any accident not brought into action, it may even remain dormant through life, and not show itself till the next generation. In mild cases the glands, after having suppurated, slowly heal; in others the eyes and eyelids are inflamed, and the joints become affected, the disease gradually extending to the ligaments and bones, and producing a hectic and debilitated state, under which the patient sinks; or it ends in tuberculated lungs and pulmonary consumption. In the treatment of the mild and simpler forms of scrofula, the diet should be nourishing and invigorating, and a dry situation and sea air are to be sought for; great attention should be paid to the clothing, so as to avoid colds and coughs; and tonics and gentle stimulants, with mild narcotics, and occasionally the alkalis, should be prescribed. Iodine has sometimes appeared of much service, but it requires the greatest circumspection in its internal use; it may be applied externally, as may also sea-water and other saline lotions. Chalybeates and mercurials are frequently prescribed; and much benefit has, in some instances, been derived from a course of sarsaparilla.

Scroll (Fr. écrou). In Heraldry, that part of the outward ornaments of a shield or achievement on which the motto is inscribed.

Scroll. In Shipbuilding, curved pieces of timber bolted to the knee of the head by way of ornament. In old naval works the word is written *scrow*.

Scrophulariaceæ (Scrophularia, one of the genera). A natural order of herbaceous or shrubby Peryginous Monopetalous Exogens, of the Bignonial alliance, inhabiting all parts of the world, except the coldest. The stamens are either didynamous or unsymmetrical; nevertheless, the affinity of the order is undoubtedly with *Solanaceæ*, through the medium of the tribe *Salpiglossideæ*; so that it becomes necessary to separate them by a mere artificial distinction, considering as *Solanaceæ* all such genera as have a plaited corolla, and five stamens, and as *Scrophulariaceæ* all those in which the fifth stamen is wanting, or the æstivation of the corolla imbricated. They are generally acrid bitterish plants. The leaves of some are purgative, and even emetic, while some, as *Digitalis*, are highly poisonous. Nearly all the tribe turn black in drying. Many of the genera, such as *Digitalis*, *Calceolaria*, *Pentstemon*, *Veronica*, *Mimulus*, &c., are valued by gardeners for their beautiful flowers.

Scrotum (Lat.). The membranous bag in which the *testes* or chief male organs of generation are suspended in the higher vertebrate animals.

Scruple (Lat. scrupulus, dim. of scrupus, *a rough stone*). A denomination of weight; the third part of a dram, and equal to twenty grains. [Weights.]

Scrutiny (Lat. scrutinium, from scrutor, *I examine*). In Parliamentary language, an examination of the votes given at an election by an election committee, at which the bad given on both sides are rejected, and the poll corrected accordingly.

Scrutiny. In the Primitive Church, an examination in the last week of Lent of the catechumens who were to be baptised on Easter-day; used chiefly in the ancient church of Rome.

Scud (Dan. skud, Swed. skudda). The name given by seamen to loose vapoury clouds driven swiftly along by the winds. *To scud*, signifies to run directly before the wind in a gale. As the object is to keep before the sea, the fore sail or foretop sail is set; the latter or the maintop sail is often necessary, as the fore sail is often becalmed from the height of the waves. *To scud with bare poles* is to run before a storm without any sail set.

Scudo. [Money.]

Scull. In a fresh-water sense, an oar, so short that one man can work a pair. In its sea meaning, it generally implies an oar placed over the stern of a boat, and worked from side to side; the blade, which is turned diagonally, being always in the water. The action on the water resembles that of the Archimedean screw. In China, where this method is well understood, large boats are impelled by a single scull with considerable velocity.

Sculpture (Lat. sculptura, from sculpo, *I carve*). The art of carving in wood, stone, or other materials. The origin of this art is a subject not less obscure than the early history of Music and Painting: and it is useless to attempt to arrive at historical conclusions, where the materials from which they might be drawn do not exist. But without venturing to determine the age at which the distinction was first established, we may classify sculptured works from the first into the two forms of carvings whether in intaglio or cameo, and of independent statues or figures. The former

branch of the art was much more practised in ancient than in modern times, owing to the universal use of seal rings, which having at first been rude signs, without meaning, and sometimes merely a square or round hole, were at length brought to perfection in the age of Phidias and Praxiteles.

The carving of independent figures seems to have been long confined to representations of deities; but we have no means of determining how long such carvings remained symbolical, or of ascertaining the age in which strictly imitative figures were introduced. It has been supposed that phrases in the Homeric poems, as in *Iliad*, vi. 303, denote the existence of imitative statuary; but this is at the least doubtful. The point of such passages lies in the placing of the peplus or robe on the figure, whatever it may have been; and as we know the use to which the PEPLUS was put in the Panathenaic festival, we are scarcely justified in assuming the existence of a more advanced art in the Homeric age, on the mere strength of a conventional epithet.

The symbolical images of gods were blocks, stones, staves, or beams. 'It was thus,' says Dr. Thirlwall, *History of Greece*, ch. vi., 'that the god of love was worshipped at Thespiæ, the goddess of beauty at Paphos, the Graces at Orchomenus, Zeus and Artemis at Sicyon, the Twins at Sparta.' These blocks or masses of stone were all conical in shape, like the images of Baal worshipped by the Phœnician and Canaanitish and Assyrian tribes. This cone was reproduced in the wooden Ashera set up in the Jewish temple at Jerusalem, on the stone altars of Baal, like the LINGA of the Hindus on the conventional representation of the YONI. These masses of wood or stone were further modified into poles or staves, which are known to have been objects of almost universal veneration. 'Even in the time of Pausanias the inhabitants of Chæronea paid higher honours to a staff, which they believed to be the sceptre of Agamemnon, described in the *Iliad*, than to any of the gods.' (Thirlwall, *History of Greece*, ib.) It is unnecessary to dwell on the connection between these conical blocks, whether of wood or stone, with the phalli or poles borne in the Dionysiac processions, or to say more than that the universality of the emblem seems to point to the conclusion that the first sculptured images or symbols were all phallic. These symbols spring up everywhere, and may in each country have led to the production of other symbols, and finally to imitations of the whole human figure. But except on distant historical evidence we have no warrant for tracing the art of one country to that of another; and the habit of tracing Greek art to Egypt seems to be in an especial degree delusive. There is not the slightest evidence that Greek civilisation, whether in music, painting, astronomy, or sculpture, was derived from the banks of the Nile, or from the cities of the great Mesopotamian plain.

This stage of the art, then, as confined to mere symbolic representation, may be dismissed as not properly belonging to the history of sculpture. Of the earlier carved works of the Jews, whether teraphim, cherubim, or any others, we do not know enough to be able to speak with certainty; but on the sculpture of the Assyrians the results of recent explorations have thrown a valuable light. From the works thus recovered from the ruins of Khorsabad, Khileh Shagat, Birs Nimrud, and other mounds, we learn that the conventional fetters which were never removed from any branch of Egyptian art were among the Assyrians confined chiefly to the representation of deities and kings. Hence in the delineation of the forms of men and beasts the Assyrian painters and sculptors attained an eminence second only to that of the Greeks. But the discoveries of Sir Henry Rawlinson, M. Botta, Mr. Layard, and others, although they carry back the history of Assyrian art to a period long preceding a contemporary history, leave the legendary annals of sculpture in the days of Ninus and SEMIRAMIS just where they were, mere fables from which no historical residuum can be extracted, even if it be contained in them.

The Nineveh marbles in the British Museum illustrate the kind of art referred to; these and those of Persepolis much resemble the Egyptian. As the Nineveh reliefs record the actions of Sennacherib in Judæa, they may be as early as the seventh century before our era, but not earlier. In Persepolis there are some extraordinary sculptures, bearing considerable resemblance to the style of the Egyptian bassi-rilievi in the palace of Thebes, allowing for the difference of dress; but they contain nothing in science or imitation particularly worthy of our notice. They appear, according to Diodorus, to have been executed by an Egyptian colony carried from Egypt by Cambyses. The earliest sculpture to which we can refer, and on which we can reason, is that of the Egyptians. The abundance and variety of the specimens still in existence of their sculpture, minute and colossal, domestic and religious, prove them to have been a nation with great resources. The greater portion of their sculpture seems to have been sacred, i. e. representations of the divinities and their attributes and qualities. Among their colossal statues, Herodotus mentions one before the temple of Vulcan at Memphis, and another at Sais, placed there by King Amasis, each of the height of seventy-five feet. The part of the sphinx, near the great pyramid, still out of the sand (i.e. from the throat upwards) rises to the height of twenty-five feet. At Thebes the sitting statues of Memnon, the mother and the sons of Osymandyas, are each fifty-eight feet high. A long catalogue might be added to these; we will, however, only add, that in the British Museum is a closed hand which must have been part of a statue sixty-five feet high. Grace of form, elegance, and symmetry, are

not to be found in Egyptian sculpture. The faces of their statues have a resemblance to the Chinese, and their bodies are formed with large bellies. They generally stand equally poised on both legs, having one foot advanced; the arms either hanging down straight on each side, or if one be raised, it is at a right angle across the body. Some of their statues are seated, and some are kneeling; the position, however, of the hands is rarely different from what we have described. The faces are generally flat; the brows, eyelids, and mouths formed of simple curves slightly marked, and with little expression. The tunics and draperies are frequently without folds.

The arts of Egypt seem to have been in a stationary state for many centuries previous to the invasion and subjugation of the country by Cambyses. Winckelmann thinks that there were two distinct styles; the first ending with the conquest just mentioned, and the second commencing at that period, and ending after the time of Alexander the Great. In the first of these styles he describes the forms as straight, stiff, and ungraceful. The sitting figures have the legs always parallel; the feet are squeezed together, and the arms fixed to the sides. In the females the left arm is generally folded across the breast, and the draperies exhibit very little skill or knowledge. In the second style the hands become more elegant; the feet are placed at a greater distance from each other, the arms hang more freely, and the figure is generally clothed with a tunic robe and mantle. The material usually employed is granite or basalt; the statues are not only formed with the chisel, but polished carefully: and the eyes are sometimes formed of different materials from the statues themselves. Small figures are frequently found, to which the name of penates has been given; they are sometimes composed of wood, sometimes of baked earth, and some are covered with a green enamel.

'Winckelmann,' says Flaxman in his Second Lecture on Sculpture, 'has remarked that the Egyptians executed quadrupeds better than the human figure; for which he gives the two following reasons: first, that as professions in that country were hereditary, genius must have been wanting to represent the human form in perfection; secondly, that the superstitious reverence for the works of their ancestors prevented improvement.' 'There are,' he continues, 'statues in the Capitoline Museum with as great a breadth, and choice of grand parts, proper to the human form, as ever they represented in their lions or other inferior animals. In addition to these observations on Egyptian statues, we may remark, the forms of their hands and feet are gross; they have no anatomical detail of parts, and are totally deficient in the grace of motion.' The Egyptian bassi-rilievi are commonly what are called sunk reliefs; they are usually sunk from the surface of the material employed, which practice most probably obtained from their being cut in very hard stone, such as granite or basalt, and from the distance at which they were usually placed above the eye. In the first case, cutting the ground away from the figure would have occupied quite as much time as carving the figure itself; and, in the second case, the range of the outline created a greater breadth of shadow and distinctness to the spectator. These bassi-rilievi, or hieroglyphics, when found on the walls of tombs, relate the profession, actions, and funeral of the deceased; on those of palaces they describe the wars, negotiations, triumphs, processions, trophies, with the civil, military, and domestic employments of kings; on those of temples they were the records of theology; and on obelisks they are hymns to the gods, or eulogies of their kings. The reliefs are invariably coloured. (Sir J. G. Wilkinson, *Ancient Egyptians, &c.*; Rosellini's *Monumenti dell' Egitto e della Nubia, &c.*; and Layard's *Monuments of Nineveh.*)

The only correct notion that can be obtained on the subject of Phœnician sculpture is from a contemplation of the medals of the Carthaginians, who were a colony from Phœnicia; though perhaps these may mislead us. The Phœnicians, known by the name of Canaanites in Scripture, were at a very early period advanced in civilisation. Beautiful in their own persons, they were, unlike the Egyptian races, themselves models for their artists, and their situation and character were favourable to the progress of the art. Their extraordinary and successful spirit of commerce led to its cultivation, and some of the statues that decorated their temples were celebrated in history. Winckelmann is of opinion that the Etrurians, or ancient Tuscans, carried sculpture to a certain degree of perfection much earlier than the Greeks. Etrurian art proves that the first attempts towards sculpture were in clay, of which innumerable specimens have been found in Rome and its environs: and as the Romans in the early period of their existence as a people were entirely ignorant of the arts, no doubt is left of these specimens being the work of the Etrurians or Volscians. Clay was for a long time the only material used—'nulla signa statuæve sine argillâ;' and Pliny and Varro tell us that the Hercules, the Jupiter Capitolinus, the quadriga on the top of his temple, and all the other statues of the gods before the temple of Ceres was erected, were 'Tuscanica omnia.' Many of the Etruscan statues bear so striking a resemblance to those of Greece, that antiquarians have thought it probable they must have been brought from that country, or from Magna Græcia into Etruria, about the period of the conquest of Greece by the Romans, when Italy became almost saturated with the magnificent spoils of art which that country yielded. The Etruscan sculpture is in two distinct styles of art. In the first or earliest style, the general lines, or contours, are exceedingly stiff and straight, and the attitudes exhibit anything but a feeling of ease in the figure: the form of the head is entirely devoid of beauty, the out-

lines not well rounded; their figures are almost invariably too slender; the form of the head is oval, the chin piked, the eyes flat, with some degree of tendency towards squinting. All these defects indicate an infant state of the art, and the very same defects are often seen in the works of the Gothic sculptors. The second style of Etruscan art is conjectured by Winckelmann to be contemporary with the age of Phidias; but this conjecture is in no way borne out or supported by proof. In this style the joints are strongly marked, the muscles raised, the bones perfectly distinguishable, and considerable knowledge of the science of anatomy is displayed. The statues of the gods are executed with delicacy, and there is a show of great power without violent distension of the muscles. The attitudes, however, are far from natural, and the action constantly overstrained. To this Millin adds a third period in the history of Etruscan art, commencing at the conquest of Greece by the Romans, at which time the Etruscan artists became acquainted with the works of the Grecians, and, adopting their style, became at first their imitators, and afterwards their rivals. To the Italian artists of this period Horace is supposed to allude in one of his satires. (Dennis, *Cities and Cemeteries of Etruria, &c.*; Winckelmann, *Storia delle Arti del Disegno presso gli Antichi*, Rome 1783.)

Before turning to the sculpture of the Greeks we may notice, as bearing some resemblance to the Egyptian sculpture, that of the Hindus. The stupendous excavations at Ellora, which have been mentioned in the article ARCHITECTURE, and those at Elephanta and other parts of India, are well known by representations which have been published in this country.

As we have seen, the first dawn of the art was on the soil of Phœnicia and Egypt: we have now to trace it in its meridian splendour on the shores of Greece.

Greek sculpture has usually been arranged under three epochs. Of the rude and unfashioned representations of the primitive or mythical ages, some mention has already been made, nor is it necessary here to touch upon the works of the so-called *Dædalids*, about which we can now form no just conception, except that the material employed by them was wood, their images being called ξόανα. About 580 B.C. it is said that Dipœnus and Scyllis, Cretans, became celebrated at Sicyon for their marble statues, which retained much of the ancient style in the advancing position of the legs, the general form of the figure, and particularly in the vertical folds of the drapery, the edges of which were zigzag. About a generation later Bupalus and Anthermus of Chios were distinguished for their work in metal throughout Greece. Soon after this period, sculpture received the most elaborate finishing, though the character of the face and limbs was not much changed from the tasteless and barbarous style of former times. Flaxman conjectures that the colossal busts of Hercules and Apollo in the British Museum may have been the works of Dipœnus and Scyllis. It is not difficult to conceive the progressive improvement in an art so much cultivated, between the time of which we are now speaking and the first epoch in which Ageladas, the master of Polycletus, appeared. This early or second period is well illustrated by the casts in the British Museum from the Æginetan marbles, discovered in 1812, and now at Munich. To this period belongs Ageladus, a native of Argos, and contemporary with Pisistratus. It was at this period that art approached the personification of ideal beauty by the choice of forms from many models, so that the excellence found in each might be combined in one. Its cultivation had become an object of necessity in most of the Grecian states, induced greatly by a practice, introduced about this era, of honouring with a statue every individual who had received three crowns in the public games. These figures of men were called ἀνδριάντες, the statues of the gods being ἀγάλματα. Such a custom afforded the artist the opportunity of contemplating some of the most perfect examples of living beauty, from which were afterwards deduced those canons of proportion on which all future art has been unable to improve. Within the interval of which we have just spoken appeared the sculptor Callimachus, to whom Vitruvius assigns the merit of having invented the Corinthian capital. [ARCHITECTURE.] 'The better drawing of the figure, with a more careful attention to its parts, more precision and variety of attitude, a less elaborate curling and dressing the hair, the form of the figure better shown through the drapery, are all certain signs of a near approach to the age of Phidias.'

The third epoch of sculpture among the Greeks was in the age of Phidias, who died 432 B.C.—a period peculiarly splendid in history, as abounding with statesmen, warriors, artists, philosophers, and poets. Athens, destroyed by the army of Xerxes, rose under the auspices of Pericles in renewed and far greater grandeur. Phidias was employed by Pericles in the superintendence of the public works; and the admiration of his powers was so universal with the ancients, that Quintilian says, speaking of his statue of Athena and the Olympian Zeus at Elis, 'Cujus pulchritudo adjecisse aliquid etiam receptæ religioni videtur, adeo majestas operis deum æquavit.' The sculptures of the Parthenon, now known as the Elgin marbles and in the British Museum, are generally considered the highest triumphs of the art of sculpture, and are assumed to be the work of Phidias and his scholars. Callicrates and Ictinus were the architects of the PARTHENON. [ACROPOLIS.] The great reputation of Phidias was founded upon his representations of the gods, excelling more in them than in human forms. In his CHRYSELEPHANTINE works in ivory and in gold he was unrivalled. Polycletus, a contemporary of Phidias, assisted in perfecting the style of the third epoch. He was of Sicyon, and especially celebrated for his Doryphoros, or lance-

bearer, and his Diadumenus, or youth binding a fillet round his head (now in the British Museum). The first was so esteemed by artists, that it was called the 'canon,' from which they studied their proportions. There is, however, some doubt whether it be this or another statue to which this honour was paid. Among the contemporaries of these great men were Phradmon, Gorgias, Myron, and Scopas of Elis. In a passage of Pliny, Alcamenes is classed with Critias and Hegias, as a rival of Phidias.

A fourth epoch, from about 360 B.C., is that in which we become acquainted with the names of Praxiteles, Scopas the Parian, and Lysippus, and in which the style termed by Winckelmann the *fine style* was introduced. The graces of youth and beauty were the delight of Praxiteles; and in his marble statues at the Ceramicus of Athens he is said to have excelled himself. His Venus of Cnidos was so endowed with charms, that her suitors came from all quarters to pay homage at her shrine. This statue, which had been rejected by the Coans on account of its being naked, was refused to Nicomedes by the citizens of Cnidos in payment of a debt of immense amount. It remained at Cnidos in the time of the emperor Arcadius, about 400 A.D. Flaxman, in his Lectures, says of it, that it 'seems to offer the first idea of the Venus de' Medici, which is likely to be the repetition of another Venus, the work of this artist.' A satyr, Cupid, Apollo sauroctonos (the lizard-slayer), and Bacchus leaning on a fawn, are known works of this master. The group of Niobe and her children, now at Florence, is ascribed both to Scopas and Praxiteles. Contemporary with Praxiteles was Lysippus, so celebrated for the group of horses still to be seen in the front of St. Mark's church at Venice. This epoch is not comparable in grandeur with its predecessor. The refinement of art was carried almost to its utmost limit: greater delicacy and voluptuousness may indeed have been, and was, introduced into the female forms, but in dignity and simplicity of feeling it is inferior to the wonderful productions of the age of Phidias. Statues were still painted at this time. [POLYCHROMY.] After this period several of the finest groups and statues were nevertheless executed: one of them, the Laocoon, now in the Vatican, is in a very high class of art, and perhaps not inferior to any group known. The principal schools of sculpture were those of Athens and Rhodes: from the latter school came the Laocoon, the Torso of Apollonius and the Colossus of Rhodes, by Chares, the scholar of Lysippus. Agesander, Polydorus, and Athenodorus, sculptors of the Laocoon, are great names of this school. The Toro Farnese, also at Naples, is the work of Apollonius and Tauriscus, sculptors of Rhodes. The Laocoon is supposed to have been made in the reign of the emperor Titus. To what extent the Rhodians were sculptors may be conjectured from the fact that the Romans carried off from their little island 3,000 statues. After the death of Alexander the Great, 324 years B.C., the arts of design seem to have declined from their meridian excellence.

Fifth Epoch.—The year 146 B.C. was signalised by the entire reduction of Greece under the dominion of the Romans. Sixty-six years previously a dawn of luxury and taste had opened at Rome by the introduction, through Marcellus, of statues from Syracuse; but though the increasing luxury of the Romans created a constant demand for fresh objects of the art, its history in the city is but a melancholy continuance of its decline. The only occupation then left for Greek artists was to be found in Rome, whither they were invited, and where very many of them were to be seen. Among them Pliny (l. xxxv. c. 12, and xxxvi. c. 5), mentions the name of Pasiteles, a sculptor, who wrote four volumes, containing a catalogue of the finest works of art known in his time. Pasiteles excelled as a statuary in metal. His silver statue of Roscius, and his vases, were highly celebrated. Arcesilaus, Zopyrus, and Aulanius Evander, all Athenians, were among his contemporaries in the Augustan age. The first of these, who excelled in marble, is extolled by Pliny for his care in modelling before he began upon the block. He was the friend of Lucullus, for whom he executed a group, described by Varro, representing a lioness with cupids sporting round her, and endeavouring to force her to drink.

Under Augustus, the art had not been entirely divested of grand and noble feeling; but after his time it partook very much of the character of his successors as they appeared. Licentious and obscene under the sway of the vicious, debauched, and cruel Tiberius, under Caligula it became so grossly flattering, that ancient Greek statues of the gods were decapitated to make room for the head of this emperor. Under Nero (to whom, however, we are perhaps indebted for the preservation of the Apollo of the Vatican and the Borghese gladiator, found in his villa at Antium) it became so extravagant, that he had himself cast by Zenodorus, as the Sun, a bronze image 110 feet high [COLOSSUS], to be placed before his 'golden house.' Vespasian cultivated the arts as well as literature. The Temple of Peace, which was really a temple of the arts, was by him decorated with the choicest specimens of Greek painting and sculpture. The reigns of his son Titus and of Trajan were also favourable to sculpture. The latter was the patron of Apollodorus, the architect. Trajan, moreover, had the liberality and good sense to erect statues in honour of the eminent men of his time. The works of this period were, however, rather architectural than sculptural, such as temples, palaces, triumphal arches, &c., and the sculpture chiefly in request was for their decoration; a want certainly calculated not so much to

retrieve the art from its sinking state as to encourage bold and off-hand execution at the expense of simplicity and expression. Hadrian not only restored the principal buildings at Athens but completed the temple of Jupiter Olympius and richly adorned the interior with statues, some of which were chryselephantine. The statue of Antinous, so generally known, was the work of this reign. Antoninus and Marcus Aurelius were appointed by Hadrian as his successors: under them the art revived for a time, and has acknowledged her gratitude to the last by his bronze statue at the Capitol. How sculpture was encouraged at this time may be gathered from the innumerable busts of these emperors that have reached us. Commodus had likewise been honoured with a multitude of statues, but these upon his death were ordered by the senate to be all destroyed. Under Septimius Severus the decay of the art became very manifest: its decline continued during the reign of Alexander Severus, though two busts of him, which were discovered a few years since, are not without merit. During the next half-century, the rapid succession of twenty emperors, scarcely one of whom died a natural death, left but little chance of a revival of sculpture. By the end of the fourth century it was nearly extinct, a fact of which no other proof is necessary than the arch of Constantine and the statues of that prince, through whose removal of the capital of the empire to Constantinople, Rome no longer swayed the sceptre of the fine arts. If the Romans do not deserve the admiration in which the Greeks are held for their knowledge of the fine arts, they deserve our gratitude for their instrumentality in preserving some of the noblest productions of the art of sculpture. There are two epochs under which the taste of the Romans for the fine arts may be classed: the first beginning with the capture of Syracuse by Marcellus, and ending at the time of Julius Cæsar; the second, that of the Augustan age, in which all the polite arts flourished.

During the early Christian period when Constantinople became the capital of the arts, and to it were gathered the chief monuments of ancient sculpture, little progress was made in the creation of new works; and during the seventh and eighth centuries nearly all that was preserved of the old was destroyed by the fanaticism of the Iconoclasts. The conquest of Constantinople by the Venetians, in 1204, the consequent dispersion of Byzantine artists, and the developement of an eastern trade, gave quite a new life to the arts, and the dawn of the classic renaissance extended over the whole West as early as the thirteenth century. This was more decidedly the case in painting and sculpture than in architecture. In middle Europe the Byzantine and Saracenic tastes prevailed; in the north, the Gothic was then being developed.

The Roman power had been entirely destroyed in the West of Europe, Italy was divided into republics and principalities, of which the chief were Venice, Genoa, and Pisa, these being the earliest in fully establishing their liberty.

First Epoch.—The Pisans, who possessed considerable extent of coast, had in the eleventh century beaten the Saracens in Africa, Sardinia, Majorca, Minorca, and Sicily; and had thus acquired the treasures with which they commenced the erection of their cathedral in 1063. It was finished in 1092, about seven years after that of St. Mark at Venice had been consecrated. Schools of painting, sculpture, and architecture soon arose after this period, and the needs of the church found employment for the talent which they produced. It has been conjectured that Buschetto, who seems to have been a Greek, was the founder of the Italian, Gothic, or Byzantine school of architecture and sculpture at Pisa. The reputation of this school was raised to the greatest height by the appearance of Nicolo da Pisa, where he was born about 1205, the pride and glory of the thirteenth century, and the first who on its restoration gave dignity and importance to sculpture. That the Grecian fragments which the Pisans had acquired soon enabled Nicolo to discriminate between them and the style of Buschetto, is evident from some remains of his work in the Campo Santo. In 1225 he was employed at Bologna in decorating the sarcophagus of St. Dominic, in which his admiration and successful imitation of the antique shine forth. He built the basilica of St. Antonio at Padua, and the church of the Frari at Venice, remarkable for its classical ornament: he was afterwards engaged on the bas-reliefs of the pulpits at Pisa and Siena. He died at Pisa about 1278. Giovanni, the son of Nicolo, succeeded his father, to whom in some respects he was more than equal. He executed the sculptures of the Last Judgment on the façade of the cathedral of Orvieto, commonly attributed to his father Nicolo; he died in 1320, and was buried in the same tomb with his father in the Campo Santo, his own work. Their figures, especially those of their draped females, are elegant, and exhibit, says Flaxman, 'an originality of idea and a force of thought seldom met with when schools of art are in the habit of copying from each other.' The school of Pisa is not limited to the two just named. Arnolfo da Lapo (1232–1300) the brothers Agostino and Agnolo of Siena, and Andrea Pisano (1270–1345), all deserve to be recorded. Andrea executed in bronze the oldest gates of the baptistery at Florence, on which is represented the life of St. John the Baptist. This work is executed (from a general design by Giotto) with much grandeur and simplicity; but in his marble statues he is inferior to his master, Giovanni Pisano. Giovanni di Balduccio, scholar of Andrea, was of this epoch: his first works were at Milan, where in 1347 he executed the mausoleum of S. Pietro Martire. In the fourteenth century Giotto established a school distinguished by good

drawing, which prepared Florence for a perfect re-establishment of the art. To it belonged Orcagna (1315–76), a name ever to be remembered for his celebrated loggia at Florence: he was also eminent for his works in sculpture. A school at Siena, towards the end of this century, produced Jacopo della Quercia, whose principal works were at Bologna, Lucca, Florence, and especially Siena, where a fountain which he executed, at the cost of 2,200 scudi d'oro, was so admired that he acquired the name of Jacopo della Fonte. From his hand are the bas-reliefs in the façade of San Petronio at Bologna. The fifteenth century was a splendid era for the production of everything great and intelligent, and most especially for the art of sculpture. The love of liberty and knowledge seemed to animate the whole of the Italian republics; and as if the republic of the arts were not excluded from the common sentiment, no individual master seems so to have outstripped his rivals as to have impressed the art with his own particular style. (Perkins, *Tuscan Sculpture.*)

This period brings us to the *second epoch* of the Renaissance, the *Quattrocento*, at the beginning of which we find six great artists engaged in a competition for executing the bronze gates of the baptistery at Florence, in which, after a year's trial, Lorenzo Ghiberti bore away the palm from his rivals. Among these was Donatello (1383–1466), a Florentine, one of the most distinguished restorers of the art. 'Some of his works,' says Flaxman, 'both in bronze and marble, might be placed beside the best productions of ancient Greece without discredit.' His alto-rilievo of two singing boys in the Duomo at Florence is, in point of character, sentiment, drawing, and drapery, of extraordinary beauty. His marble statue of St. George standing upright, equally poised on both his legs, with his hands resting on the shield before him, so excited the admiration of Michael Angelo, that, after contemplating it in deep silence for a considerable length of time, he is said to have exclaimed suddenly, 'March.' Lorenzo Ghiberti (1381–1455) has immortalised himself in the work for which he bore away the prize from Donatello: from the eulogy bestowed on them by Michael Angelo, they bear the appellation of the 'Gates of Paradise.' Ghiberti made two sets of gates for the baptistery. This undertaking occupied forty-nine years of his life, from 1403 to 1452, and still, notwithstanding the criticism of Reynolds, remains one of the noblest monuments of modern art. The subjects are from the Old and New Testaments; and the complaint of Reynolds is, that 'the landscape and buildings occupy so large a portion of the compartment that the figures remained but secondary objects, entirely contrary to the principle of the ancients.' A cast of the 'Old Testament' gates is at the South Kensington Museum. Brunelleschi (1377–1444), the intimate friend of Donatello, better known by his high acquirements as an architect, was not less a sculptor of considerable eminence; at Florence, in the church of Sta. Maria Novella, is an admirable crucifix by him in wood. In 1470, Andrea Verrocchio was found amongst the first rank of sculptors in Florence; he was the master of Pietro Perugino and Leonardo da Vinci, and executed at Venice the famous figure of Bartolomeo Coleoni of Bergamo, on horseback. Antonio Begarelli was distinguished at Modena. We now come to Michael Angelo Buonarroti, whom we have once more [ARCHITECTURE; PAINTING] to introduce to the reader's notice as the most eminent of modern sculptors, as well as of architects and painters. The energetic works of this extraordinary man seem rather the result of inspiration than of genius, and with him is introduced

The *third epoch*, that of the *Cinquecento*, in which the perfect restoration of the art was accomplished. His own works, however, are, in spite of their great power, not free from manner; he was too ostentatious of anatomy, and his heads are usually too small for the limbs; though, in the case of his David, of which there is a cast at South Kensington, it is the body which is too small for the head and limbs. Many of Michael Angelo's works in sculpture may be seen in casts at the Crystal Palace. Vasari, the historian of the painters, sculptors, and architects, wrote the life of Michael Angelo while he was yet living, and thus justifies himself for so doing: 'Let none be surprised that I have here written the life of Michael Angelo, who is yet living. Indeed, it cannot be expected that he will ever die, and therefore it has appeared to me proper to do him this little honour; for when in common with other men his life shall pass away, he will be immortal in his immortal works, the fame of which, as long as the world lasts, will live with glory in the mouths of men and in their records, in contempt of envy and despite of death.' Michael Angelo was nobly descended, and at the early age of fifteen was patronised by Lorenzo de' Medici, who took him into his house, and continued his friend until his death in 1492. His career in sculpture was commenced by a sleeping Cupid, a Bacchus and young fawn, and a group of a Madonna sitting with the dead Christ on her knees, executed in 1499 at Rome, and his colossal David, made out of a single block, for the Piazza Granduca at Florence in 1502; works which raised him immediately above his contemporaries. It is not our purpose here to touch upon the productions of Michael Angelo in the other two arts which occupied a great portion of his time, and which it appears he afterwards regretted; for Condivi, his biographer, observes, 'Che mi rammenta udirlo dire che quando la (the basso-rilievo of the battle of Hercules with the Centaurs) vide, cognosce quanto torto egli abbia fatto alla natura a non seguitar prontamente l'arte della scultura.' Julius II., on being raised to the papal chair, employed Michael Angelo on a

mausoleum for himself, which it was intended to place under the centre of the dome of St. Peter's. It was projected on a most magnificent scale; but being subjected to many delays, and the pope dying, only one of its sides was completed, and thus was afterwards erected in the church of San Pietro in Vinculis by order of his nephew. In this monument is found the celebrated Moses and some other statues, partly executed by Michael Angelo, and partly by his pupil Raffaello da Monte Lupo: the monument was completed in 1550, it having been through various interruptions no less than forty years in progress. It is mortifying to know that a large portion of this artist's time was wasted at the quarries of Pietra Santa, owing to the misconduct of the underlings of Leo X. Cardinal Giuliano de' Medici, in 1523, engaged him on the sacristy and library of San Lorenzo. In the Capella dei Depositi, or sacristy, are the statues of Lorenzo and Giuliano de' Medici seated, and in Roman military habits: the former is conceived with a simplicity worthy of the highest era of Grecian art. The recumbent statues of Daybreak and Night, under the statue of Giuliano in the same chapel, 'are grand and mysterious: the characters and forms bespeak the same mighty hand and mind evident throughout the ceiling of the Sistine chapel and Last Judgment.' They are in casts at the Crystal Palace. He died on February 17, 1564, having nearly completed his ninetieth year. Flaxman, in his Tenth Lecture on Sculpture, closes his account of him thus: 'The character and works of Michael Angelo have been dwelt on at greater length, because, as his mental and bodily powers continued far beyond the usual date of human life, his diligence attained to so much greater perfection in the principles of art. Anatomy, the motion and perspective of the figure, the complication, grandeur, and harmony of his grouping, with the advantages and facility of execution in painting and sculpture, besides his mathematical and mechanical attainments in architecture and building, together with the many and prodigious works he accomplished, demonstrate how greatly he contributed to the restoration of art.' 'Michel,' says Ariosto, 'più che mortal, Angel' divino.'

After this epoch, or perhaps almost belonging to it, appeared Giovanni da Bologna, or John of Bologna (1524–1608), a Fleming so called for his fountain surmounted by Neptune, in that city. He was a sculptor of extraordinary merit, and eminent for his works in bronze and marble. His Venus coming from the Bath is delicate and graceful; and the group of the Rape of the Sabine women, in the grand piazza at Florence, is extremely well composed, and possesses a fine undulation of line. The Mercury also, springing from the Wind, is energetic and original. There are many small works extant by this artist. Benvenuto Cellini (1500–71), another follower of Michael Angelo, was one of the strangest and most eccentric characters that ever existed. He was chiefly employed as a goldsmith and sculptor in metals; but was frequently engaged on large figures and groups, of which the Perseus holding the head of Medusa in his left hand, in the Piazza Granduca at Florence, is a splendid example. Other real disciples of the great Tuscan master were Raffaello da Monte Lupo, his favourite pupil and assistant; Nicolo Tribolo, who executed some works for the façade of the cathedral at Bologna; and Vincenzo Danti. Of this time also are Baccio Bandinelli (1487–1562), a man of considerable talent, but greatly inferior to Michael Angelo, though he set himself up as a rival and competitor; Giovanni dell' Opera, a distinguished scholar of Bandinelli; Baccio da Monte Lupo, the father of Raffaello, who executed the wooden crucifix in the refectory of San Marco; Andrea Contucci, a clever and occasionally successful competitor of Michael Angelo, and founder of the school of Loretto; Francesco Rustici, a pupil of Leonardo da Vinci, but whose works evince a devotion to the style of Michael Angelo, and who introduced it into France; and Jacopo Tatti (1479–1570), commonly called Sansovino, who was the head of the Venetian school of sculpture. As an architect he was an artist of surprising talents, as is manifest from his works at Verona; his sculpture, however, is deficient in purity, though not in richness of composition. His principal pupils were Danese Cattaneo and Alessandro Vittoria. The principles of the school were diffused through Italy, and were equally to be seen in Lombardy and Naples: in the latter city the principal masters were Marliano da Nola and Girolamo Santa Croce. At Milan were Agostino Busti, and Guglielmo della Porta, whose reputation was raised by the statues executed by him on the tomb of Paul III. in St. Peter's. These have been esteemed as among the best examples of modern sculpture. Torregiano, who also belongs to this period, was, like Benvenuto Cellini, of a vagabond disposition, but a man of genius; he was invited over to England, where he wrought upon the tomb of Henry VII. at Westminster, for which he received the sum of 1,000*l*. He died, a prisoner of the Inquisition, at Seville, in 1522. In England, also, we had Giovanni da Padua in the following reign. Of native sculptors, William Austen, the artist of the Beauchamp tomb at Warwick, 1452, and a London founder, was not unworthy to rank with his Italian competitors in the fifteenth century.

Spain produced some celebrated sculptors in the sixteenth century, their first native artist being Berruguette, a pupil of Vasari and Michael Angelo. Berruguette's disciple, Paolo de Cespedes, the painter, of Cordova (1538–1608), is reputed the greatest sculptor that Spain ever produced.

It does not appear that Germany produced any sculptors of eminence before the seventeenth century. But in France, Jacques d'An-

goulême, who had been at Rome, where he had a competition even with Michael Angelo; Jean Gougeon (1510–72), who finished the Fountain of the Innocents at Paris in 1550, and is said to have been one of the victims in the massacre on St. Bartholomew's Day; Jean Cousin, whose works, though deficient in force and truth, yet exhibit much grace and delicacy; and Germain Pilon, whose detail is remarkable for its beauty—are names that entitle that country to a high rank among the nations of Europe, in which all the works of sculpture that were produced are so many testimonies of the influence which the genius of Michael Angelo exerted over the arts: though the French school is in its taste more directly allied to Parmigiano and Primaticcio.

At the commencement of the seventeenth century, Bernini, a native of Naples, born in 1598, raised himself to employment before unknown. Endowed with all the qualities necessary for becoming a great artist, and desirous of distinguishing himself by the foundation of a new school, he plunged into caprice and complexity, and, preferring effect to simplicity, effaced all traces of the style which from the time of Michael Angelo had prevailed in Europe. His draperies, founded on the paintings of the Bolognese school, his affected style, the violent expression in which he delighted, are the marks of an ambitious artist, whose only aim was to be striking. He deluged Italy with his works, and corrupted it with his taste till his death in 1680. The most celebrated contemporaries of Bernini were Algardi (1593-1654) and Duquesnoy (1594–1643), commonly called Il Fiammingo. The latter is much esteemed for his representations of youth, and particularly of infants. At Naples he executed a concert of cherubs, and two infants on a monument at Rome, which are his most admired works: the latter was particularly admired by Rubens, who says of it, 'Nature rather than art appears to have sculptured them, and the marble is softened into life.' Camille Rusconi in Italy succeeded to Bernini, and was the sculptor most in request at the beginning of the eighteenth century. His greatest works were those of San Giovanni in Laterano, where he was assisted by Monnot, Le Gros, Moratti, and Ottoni: he died in 1728. The further progress of sculpture seemed now impossible; in short, the art seemed to have departed, though men whose names are not worth recording, with all the pretensions of artists, still hovered about the scenes of its former glory. In England, Grinling Gibbons, a native of Rotterdam, was distinguished both as a statuary in bronze and a carver in wood; he died in 1721.

In France, Stefano della Bella, and Pietro Tacca, pupil of Giovanni da Bologna, occupy the interval up to the beginning of the reign of Louis XIV.—one extremely creditable to the French school, François and Michel Anguier being among the most distinguished. In the remaining period of that monarch's reign, the principal sculptors were François Girardon, born at Troyes in 1630, and Pierre Paul Puget, born at Marseilles in 1622, the latter of whom, from his fiery and energetic style, received the appellation of the Michael Angelo of France. These two were the head of the school of the succeeding sculptors of France, which comprised Desjardins, Antoine Coysevox, Pierre Francville, Pierre le Gros, Nicolas Coustou. To this school also belonged Étienne Falconet, celebrated for his writings, and for the equestrian statue he executed at St. Petersburg of the Czar Peter. The unfortunate Louis XVI., previous to the Revolution, was a great patron of sculpture, and had projected a collection of statues of the most eminent characters of the country. J. B. Pigalle, the sculptor of the day, had executed some of them before the dreadful period which stopped in France for a time all cultivation of the arts. The school of Pigalle was of considerable extent and influence, Mouchy, Bocquet, Moette, Chaudet, and Lebrun, being members of it, and continuing the art to within a generation of the present century. Of the recent sculptors of France, James Pradier, a Swiss (1792–1852), has acquired perhaps the greatest name. Contemporary, or nearly so, with these in Germany, were Rauchmüller of Vienna, A. von Schlüter at Berlin, N. Millich at Stockholm, and others; subsequent to whom are Ohnmacht, Sonnenschein, and Nahl of Strasburg, all sculptors of much reputation.

Our knowledge of Spanish sculptors is so limited, from their reputation not travelling away from their own country, and indeed being little known in Spain itself (except in Madrid and the chief cities, where the principal employment for them is the decoration of churches), that probably little interest would be created by an enumeration of them.

In England, up to a late period, the most celebrated sculptors were foreigners. C. G. Cibber, L. F. Roubiliac, and Peter Scheemackers had the sway; and monuments of their genius, especially of the second, are the pride of some of our churches.

The art, however, seemed to be near its dissolution, when Antonio Canova, in 1787, revived in Rome the purity without which it is worthless. This justly admired sculptor was born in 1757, at Possagno, a village amidst the Asolani hills, at the foot of the Venetian Alps. Pietro his father, and Pasino his grandfather, were sculptors, whose labours were chiefly confined to the churches of the district. Deprived of his father when only three years of age, he was indebted to his grandfather for the early instruction and employment of the chisel, by which he acquired great mechanical dexterity. Attracting the notice of the patrician Giovanni Faliero, he was by him placed with Torretto, one of the best Venetian sculptors of that day. Torretto soon afterwards died, and young Antonio then studied under Torretto's nephew, Ferrari. But he soon broke through the trammels of the art as it was then practised; and the rapidity of his progress

having induced his patron to find a more appropriate theatre for the exercise of his powers, the young artist was sent to Rome in December, 1780, soon after which time the Venetian government granted him a pension of 300 ducats for three years. At this period the fashionable sculptors of Rome were Agostino Penna, Pacili, Bracci, Sibilla, and others, whose productions are already forgotten: so that in the way of emulation Canova had little to excite his talents. Before the period had expired for which his pension was granted, the zeal of Volpato had been successful in procuring for him the commission to execute the monument of Clement XIV. (Ganganelli). Thus was afforded to the young sculptor an opportunity of exhibiting his powers to a public who were fortunately capable of appreciating his merit. Before the expiration of the eighteenth century he had produced an amazing quantity of works, at which time it was not the practice (one afterwards introduced by him) to employ inferior workmen to reduce the block to the last shape of the superficies. The enumeration of his works would occupy much more space than can be here assigned to them: they were often deficient in energy, but generally abounding in grace and elegance; and in his monumental sculpture there is a vast originality of invention, whilst it is free from extravagance. His females are voluptuous, but not offensively so; his execution of them is exquisite. In the monument executed in memory of the archduchess Christina of Austria, there is a pathos in the composition, the figures of which are linked together with the chain of nature in a manner worthy the divine Raphael himself. Canova died at Venice on October 13, 1822; and his remains were removed to his native place, in which he had erected, at his own expense, a splendid church. Albert Thorwaldsen (1770-1844), a contemporary of Canova, but much his junior, a native of Denmark, has by his great, though irregular and erratic, genius, raised himself to eminence throughout Europe as well as Rome and in his own country. His powers in basso-rilievo are great; but in his female figures he wants grace. Some distinguished names have also of late adorned the annals of the art in Germany: as Heinrich Dannesker of Stuttgardt (1758-1836); Ludwig Schwanthaler of Munich (1802-48); Christian Rauch of Berlin (1777-1857); and J. M. Wagner of Würzburg (1773-1858).

In England, the able sculptors John Bacon, Thomas Banks, and Joseph Nollekens, were followed by John Flaxman—a name honourable to the arts of this country. Intense feeling and simplicity characterise all his works; and in epic sculpture he perhaps surpassed Canova. He was born at York in 1755, and died in 1826. The lectures which he delivered as professor of sculpture at the Royal Academy have been published. (*Lectures on Sculpture, &c.*, with fifty-two plates, 2nd edition, 1838.) Sculpture has made great progress in England since the days of Flaxman. Not to mention living men, a very respectable array of names may be selected from the list of deceased sculptors: Sir Francis Chantrey (1782-1841); Sir Richard Westmacott (1775-1856); J. C. F. Rossi (1762-1839); Samuel Joseph (1791-1850); Richard Wyatt (1795-1850); John Hogan (1802-58); Benjamin Wyon (1802-58); M. L. Watson (1804-47); John Gibson (1780-1866), and Matthew Cotes Wyatt (1778-1862), the sculptor of the equestrian bronzes of George III. in Cockspur Street and of the Duke of Wellington at Hyde Park Corner, the last the most absurdly placed monument in Europe. For a general history of modern sculpture the reader is referred to the illustrated work of Count Cicognara,—'The History of Sculpture from its rise in Italy to the century of Canova, to serve as a continuation of the works of Winckelmann and of D'Agincourt.'

Sculpture, Practice of. The work of the sculptor is generally limited to modelling in clay; from this model a plaster cast is taken, and from the cast the marble figure is copied by carvers aided by the pointing machine.

A model as large as the intended figure or group is first made in clay. It is placed on a stand or banker with revolving top called the sculptor's easel; and the general form is got out with the hand and fingers, small box-wood or wire tools being made use of to shape the parts that the fingers cannot reach. The clay is kept moist, to prevent its shrinking, till the model is completed. The model is then moulded in plaster of Paris, before it begins to dry, whence a matrix is formed, into which plaster is introduced; and the matrix being broken away from it, the model in clay is thus transferred into one of plaster. This becomes the standard from which the artist takes all the measurements for the figure he is about to execute. The block of marble and the model being now placed on stands, with a graduated rod, which moves on a frame perpendicular to it, and has a point attached to it which can be made to advance and recede at pleasure, certain prominent points are selected and marked in the model, and their distance measured on the frame longitudinally and vertically, and also the distance that the point on the rod is advanced or receded in order to touch a given point. This being found on the outside of the rough block, the particular point is drilled down to as great a distance as was measured in the model. This operation being repeated for a great number of points, the surface is worked away to all the several points found as above, till at last it assumes the general form of the model. As the sculptor approaches the surface which is to be left when finished, more caution and finer tools become necessary, till at length it is brought into a state for his finishing touches. This purely mechanical process of bringing the shapeless block into something like the form which it is ultimately to bear is performed by workmen, thus effecting a great saving of the artist's labour and time [Modelling; Wax Modelling.]

Scupper (Span. escupir). A hole in a ship's deck or side to carry off the rain or water shipped. Means should be at hand to plug scuppers when the ship rolls them below the surface.

Scurvy (Low Lat. scorbutus). This disease, once so common in our navy, is now of very rare occurrence. It generally appears to be connected with debilitating causes, and especially with unwholesome food, want of exercise, cold and moisture. It begins with indolence, sallow looks, and loss of strength and spirits; the gums become spongy, the teeth loose, the breath fetid; livid eruptions appear on different parts of the body, known as *petechiæ* and *vibices*, and at length the patient sinks under general emaciation, diarrhœa, and hæmorrhages. In the prevention and cure of this disease, much is effected by attention to diet and cleanliness. Fresh vegetables, farinaceous substances, and brisk fermented liquors, good air, and due exercise, are among the principal remedial means. Acids, and especially lemon juice, have been much extolled.

Scutage (Lat. scutum, *a shield*). In Feudal Law, scutage was a commutation for personal service in foreign wars, paid by military tenants: made general in England, under Henry II. in 1159. [Escuage.]

Scutate (Lat. scutatus, from scutum, *a shield*). In Zoology, when a surface is protected by large scales.

Scutellum (Lat. scutum). In Botany, a term used by Gærtner to denote the small cotyledon on the outside of the embryo of wheat, inserted a little lower down than the other more perfect cotyledon, which is pressed close to the albumen. Also the shields of some kinds of Lichens, as *Parmelia*.

Scutibranchians (Lat. scutum; branchiæ, *gills*). A name given by Cuvier to an order of hermaphrodite Gastropodous Molluscs, including those which have the gills covered with a shell in the form of a shield.

Scutigers (Lat. scutum; gero, *I carry*). The name of a genus of unequal-legged Chilopodous Myriapods, which frequent houses and out-buildings in the South of Europe, and prey upon insects, wood-lice, and other small creatures.

Scutipeds (Lat. scutum, and pes, *a foot*). The name given by Scopoli to one of the divisions in his binary system of ornithology, including those birds which have the anterior part of the leg covered with segments of unequal horny rings terminating on each side in a groove.

Scuttle (A.-Sax. scyttel, Span. escotilla, Fr. écoutille). An easily closed opening in the ship's side or deck to admit light or air, or for communication.

To scuttle the decks, implies to cut holes to let the water down from them into the hold, as in the case of fire.

To scuttle a vessel, is to cut a hole in her for the purpose of sinking her.

Scuttle Butt. A cask of water with a large hole in it placed for use in a ship.

Scutum (Lat.). The shield of the Roman heavy-armed legionaries: made of wood, defended with plates of iron, and covered with leather. It was either oval or of semi-cylindrical shape. In the centre was a boss of brass or iron, projecting from the shield. From this word is derived the modern term Esquire.

Scylla (Gr. Σκύλλα). In Greek Mythology, a daughter of Nisus, king of Megara. When Minos came from Crete to take vengeance for the death of his son Androgeos, his efforts to take the city were fruitless as long as the purple lock on the head of Nisus remained unshorn. Urged by her love for Minos, Scylla cut off the fatal lock, and with it destroyed the life of her father and the safety of the city. According to one version, Minos tied Scylla to the stern of his ship and drowned her; but another tale says that she was changed into a fish which Nisus, transformed into an eagle, constantly pursued. The myth was localised in the names of the port of Nisæa and the promontory Scyllæum.

The *Odyssey* (xii. 73, &c.) speaks of another Scylla, a daughter of Cratæis, as a monster with twelve feet, six necks, and six mouths, each containing three rows of teeth. This being haunted a rock on the Italian coast; a neighbouring rock being tenanted by Charybdis, who thrice every day swallowed the waters of the sea, and thrice threw them up again. Like Medusa, Scylla is represented in some legends as having been beautiful, and as having been changed into a monster through the jealousy of Circe or Amphitrite.

Scyphus (Lat.; Gr. σκύφος, *a cup*). In Botany, a cup or coronet, such as occurs in the *Narcissus* and allied plants. Also, in Lichens, a cup-like dilatation of the podetium, bearing shields upon its margin.

Scytale (Gr. σκυτάλη). An instrument used by the Lacedæmonians for the conveyance of secret instructions to their commanders. The construction of it was as follows: When a general was sent out, a black rod was given him, while another of exactly similar dimensions was preserved at home. When instructions were to be sent out, a strip of parchment was wrapped round the rod and on the folds the orders were written; these he read by unrolling the parchmen with the rod in his possession.

Scythian Lamb. One of the names of the fern called by botanists *Cibotium Barometz*.

Sea (for the origin of the word, see Soul). The expression employed by sailors to describe the condition of the waters they are traversing. A *long sea* is one in which the crests of successive waves are distant from each other, and in which the effect upon the ship is a heavy rolling motion. A *short sea*, on the other hand, is when the waves are frequent, irregular, and crowned by foam. They produce a pitching motion. A *cross sea*, the most irregular, is when a change of wind or a current drives one succession of waves in a direction different from that of another series resulting from the swell caused by a former storm.

Sea. In Geography. [Ocean.]

Sea and River Defences. The walls, embankments, or other constructions intended to protect coasts and river banks from the destructive action of the waves, or from the erosive action of flowing water. In some countries, such as Holland, where a large part of the land is below the level of the sea, disastrous inundations are only to be prevented by a system of dykes or sea embankments which shall be sufficiently heavy and sufficiently tight to prevent the entrance of the water, and which shall be faced with materials sufficiently strong to resist the force of the sea. Rivers flowing through alluvial districts, such as the Ganges or Indus, are apt to wander about, and require to have their channels fixed, which is best done by brushwood, the friction of which upon the water arrests the velocity of the flow in that part, and which soon consequently becomes silted up.

There is much difference of opinion among engineers as to whether sea-walls intended to encounter the shock of the waves should be vertical, from the face of which the waves will be reflected, or inclined like a beach, so that the waves will expend their force upon it in friction and be broken up. Much manifestly depends upon the depth and nature of the bottom. If a vertical wall deflects a wave, it will deflect it downwards as well as upwards, and if the bottom is weak and not distant, it may be undermined by the deflected water, and the wall may tumble down. In cases, however, where these objections do not exist, the vertical wall appears to be the best, since, instead of exhausting upon itself the force of the waves, it enables the waves to take a new direction without having been robbed of much of their momentum which will be finally expended on the sea-shore. In Holland many of the dykes have a long fore shore to break up the waves and dissipate their energy before they reach the main structure, and this provision is generally adopted on the Essex coast and elsewhere. The best material for the heart or body of a sea-wall is stiff clay, but even this material requires to be carefully packed to prevent percolation. In Essex the clay is dug from the fore shore in spits, and packed into a sea-wall by an operation termed *flood flanking*. The spits are delivered by the barrow men to the packers, who, taking each spit on a pitchfork, strike it forcibly into its place. The crevices produced by the shrinkage of the spits in drying are filled with mud, which is called *sludging*. Peat or bog is sometimes used for sea-walls, and it is fibrous and tough, but light, and requires to be weighted with stone. Gravel is valuable for the formation of an artificial beach at the foot of the wall, and which also serves as a road. Usually sea-walls are faced with stone, and by spreading gravel over this facing the small stones insinuate themselves and wedge the large stones together. If the embankment is made with a great slope seaward, it will sometimes be sufficient to cover the slope with gravel so as to form an artificial beach.

The Roman embankments formed on the coasts of Essex and Lincolnshire, and also on the lower parts of the Thames, consist of steep mounds of earth defended by rows of piles, the spaces between the rows, or *rooms*, as they are called, being filled up with chalk. Modern embankments consist of three parts: First, the *main* bank, about 20 feet wide at top, with a rise of tide of 10 feet, and formed with a slope in the lower portion of 5 to 1, and in the upper portion of 4 to 1; secondly, the *outburst* bank, 5 feet high and 8 feet wide at top, placed on top of the foregoing, formed with a slope of 1½ to 1; and thirdly, the *swash* bank, 2½ feet high and 2½ feet wide at top and 8 feet wide at bottom, placed on top of the outburst, and which is supposed to arrest only the tops of the waves. The embankments should be faced with stone laid on a solid facing of clay in all cases where the exposure to the waves is great; but in other cases it will be sufficient to coat that portion above ordinary spring tides with gravel and clay, and to cultivate upon it couch-grass, ray-grass, and lucerne. If the materials are too weak to stand without injury until these grasses grow, the surface should be turfed over. In Holland some of the dykes are thatched on the sea side, and some are made with a timber framework, within which the stone facing is fitted. At some distance from the embankment on the inner side a ditch is dug to carry off any infiltration.

On some coasts groynes, or walls of timber or stone carried down into the sea, are employed to arrest the movement of the shingle coastwise, and thus to create a natural embankment. Important sea-walls and piers are sometimes formed of béton or concrete, formed into square blocks and then used as stones. Sometimes also the béton is lowered while still soft in a bucket with tilting bottom into the water, and is then let out on the surface of the ground, whereby an artificial rock is built up.

The foundation for river walls or other constructions on the banks of rivers in alluvial countries, such as Bengal and the Punjaub, require to be formed with wells according to the native practice; or screw piles or iron cylinders may be substituted. For further information respecting sea and river defences, the reader may consult Lamblardie, *Sur les Côtes de la Normandie*; Syanzius, *Cours de Construction*; Minard, *Cours des Travaux Hydrauliques à la Mer*; the *Annales des Ponts et Chaussées*, passim; Romano, *Sulle Lagune di Venezia*; Galileo, Frisi, Guglielmini, &c., *Tracts upon Hydraulics*; Page's *Report on the Drainage of the Fenland*; Coode *On the Portland Breakwater*; the *Reports on the Formation of Harbours of Refuge*, presented to the House of Commons; and the Dutch and German works upon the defence of the sea-shores, and upon the preservation of the bank of the Rhine and other rivers, in those countries.

Sea-anemone. The name of a highly organised Polype of the genus *Actinia*.

Sea-bear. A vulgar epithet applied inaccurately to several large species of seals. The use of such words is much to be deprecated.

Sea-boat. A term applied by seamen to a vessel, as respects her qualities in bad weather.

Sea-devil. The seaman's name of a large cartilaginous fish of the Ray tribe, the type of the genus *Cephaloptera*, Cuvier; also applied to the angler (*Lophius piscatorius*, Linn.).

Sea-girdles. The common name for the alga *Laminaria digitata*.

Sea-hare. [Aplysia.]

Sea-holly. The *Eryngium maritimum* of botanists, a harsh spiny-leaved sea-side plant.

Sea-horse. The term is most correctly given to a small Lophobranchian fish found in the Mediterranean, the *Hippocampus*. It is also sometimes applied to the Walrus (*Trichechus rosmarus*) a large phocine mammal, found in the Arctic Ocean.

Sea-jellies. A vulgar name for the animals allied to the Medusa.

Sea-kale. [Crambe.]

Sea-mew. A name for the gull, derived from the French *mouette*. [Larus.]

Sea-otter. The *Enhydris inunguis*, a genus of Lutrine Carnivora, the fur of which is much sought after, and whose toes are webbed together to a greater extent than in the true otters. [Lutra.]

Sea-pink. One of the names of the Thrift, *Armeria vulgaris*.

Sea-serpent. This word, with the common prefix *Great*, represents the idea of a surface-swimming, air-breathing, marine animal, of a snake-like shape and undulatory motion, variously reported by alleged eye-witnesses as being from 100 to 600 feet in length; and, by most, as having a *mane*. The best attested instance is that which was said by several independent witnesses to have been seen off the island of Stronsa, in the Orkneys, in 1808. Their reports on affidavit before the local authorities are embodied in the paper by Dr. Barclay in the first volume of the *Wernerian Transactions of Edinburgh*. In this paper that anatomist gave an account of the vertebræ of the supposed animal which had been cast upon the rocky shore of the island during a great storm, shortly after its appearance off the coast had alarmed the fishermen. Two of the vertebræ had been fortunately sent to the museum of the London College of Surgeons; their true nature was recognised by Owen, and described in his catalogue of the Osteology in the Museum (4to vol. i. p. 98, 1853) as vertebræ of the great basking shark (*Selache maxima*, Cuv.). The appearance, interpreted as the sea-serpent, had been caused by the alternate rise and fall, on the surface of the sea, of the dorsal fins of two individuals, probably male and female, of the basking shark, closely following each other. Both had been driven ashore by the storm; and, being afterwards discovered in a decomposed state, their back-bones were put together lengthwise, as of one animal, by the fishermen, making a total of upwards of sixty feet in length.

Many and divers are the phenomena at sea which recall the preconceived notion of the great sea-serpent; and, viewed in that frame of mind, a distance too great for accurate observation, leave a conviction of the marvel which is testified to in good faith. Whenever the monster has been closely approached or captured, it has turned out to be other than was supposed. Captain Sir James C. Ross, in his antarctic voyage, ordered out a boat to approach and if possible kill and capture what seemed to him, his officers, and crew, to be a veritable sea-serpent. It proved to be the great sea-elephant, *Phoca* (*Cystophora*) *proboscideus*, nearly thirty feet in length, but leaving a strong wake of more than twice that length through the powerful action of the tail-propeller. In other instances, the supposed sea-serpent has proved to be a succession of grampuses or porpoises tumbling in line, one after another, and deceiving the eye as a continuous undulatory body, when first seen at a distance; or it has been found to be a log or spar covered with barnacles and sea-weed, which, lifted by the waves and falling, represented the mane of the preconceived monster. Professor Owen's letter in the *Times* of May 10, 1849, 'On the sea-serpent alleged to have been seen by Capt. McQuhae, of H.M.S. Dædalus,' gave a blow to the animal from which it has never recovered. Since the publication of his recommendation in the *Admiralty Manual of Scientific Enquiry* (*Zoology*), the accounts of the true causes of the appearance have multiplied, and the newspaper paragraphs of the fabulous cause have grown scarce.

'When an object is seen afloat, attracting notice by its magnitude or other peculiarity, and is not captured, its nearest approach to the ship, its mode, course, and rate of progression, and the parts actually recognisable, should be noted at the time with the utmost accuracy. If practicable, a boat should be put off for close observation. If the observer has not the zoological knowledge, or the opportunity for exact inspection, requisite for determining the species from the phenomena, he should abstain from giving the object any special name. Supposing it to be an animal, a shot fired, if it do not hit, may so alarm the creature as to cause some sudden movement which may reveal more of its true nature' (p. 50). This recommendation should be followed in all cases of phenomena simulating the great krakens and sea-serpents.

Nevertheless, sea-serpents do exist: they even abound in some localities in the tropics; they belong to the genus *Hydrus* or *Hydrophis*, and are distinguished from land serpents by their compressed tail, which thus becomes a swimming organ. The species are commonly from two feet to four feet in length; rarely, approaching to ten feet. There is no à priori reason why such sea-serpents should not rival or surpass the whale in length: but, owing to the long and large lung-like air-bladder which, as serpents, they would possess, they would usually float some time after death: and it is hardly

conceivable that some of the vertebræ should not have been met with on the coasts of America or Norway, where (according to Pontoppidian and Hans Egede) the monster has been most commonly witnessed, if it had ever existed as a species, represented by the numerous individuals of countless successive generations since creation. The fishes which, after *selache*, have been found to raise the notion of the sea-serpent, are those of the tænioid family or *riband-fishes*; of which the species called *Gymnetrus Banksii* has furnished specimens of nearly 20 feet in length, cast ashore on the coast of Durham and Northumberland. The idea that some lingering representatives of Mesozoic sea-reptiles (*Ichthyosaurus, Plesiosaurus*) may have originated the notion of the great sea-serpent, has been entertained by some who were ignorant of the laws of palæontology.

Sea-sickness. Nausea and retching, which attack most persons on first going to sea; sometimes continuing only a day or two, but often lasting the whole of a long voyage. In some persons its violence is prevented by small doses of opium or by soda water, or saline draughts in the effervescent state. Liniments and plaisters containing opium applied to the pit of the stomach have also been recommended, as mitigating, or even preventing, this most annoying malady. The violence of the attacks not only varies in different individuals at different times, but the same person who escapes in one voyage may suffer severely in another. Dr. John Chapman, who has recently proposed the application of ice to the back as a remedy for this malady, holds that the proximate cause of sea-sickness consists in an undue amount of blood in the nervous centres along the back, and especially in the segments of the spinal cord related to the stomach, and the muscles concerned in vomiting. (*Functional Diseases of the Stomach*, part i.; *Sea-sickness, its Nature and Treatment*, London, Trübner, 1864.) This excess of blood can, he maintains, be reduced by the application of ice, which is a direct sedative to the spinal cord, if placed immediately over it, by lessening its functional and especially its automatic or excito-motor power. This remedy, which Dr. Chapman states has been applied with singular success in cases of sea-sickness, he believes to be likewise applicable in other diseases which have hitherto more or less baffled medical treatment.

Sea-thongs. One of the names for the British alga *Himanthalia lorea*.

Sea-trumpet. The common name for the alga *Ecklonia buccinalis*.

Sea-unicorn. The colloquial name for the narwhal (*Monoceros*), a large species of true Cetacean, in which one of the canine teeth in the upper jaw is extraordinarily developed, and forms a spear-like bone of a spiral form used by the narwhal as a powerful weapon.

Sea-urchin. The name generally applied to the different species of *Echinus*.

Sea-weeds. [ALGÆ.]

Sea-wolf. The *Anarrhichas lupus*, a fish, is often so called in reference to its powerful teeth and its destructive carnassial habits.

Sea-wrack. The sea-weed thrown up by the tide, and collected by farmers and others for the purpose of manuring cultivated land. The name is also applied to *Zostera marina*.

Seal (Fr. sceau, or scel; Lat. sigillum, dim. of signum). In Gem Sculpture, a stamp cut or sunk on stone, capable of yielding an impression to any soft substance. When a gem is selected for cutting, it is put into the hands of the lapidary to reduce it to shape and smoothness. It is then fixed with mastic to a piece of wood to serve as a handle, and the subject is sketched upon it with a copper point or a diamond. The tool is a lathe somewhat resembling a turning lathe, and into the end of the spindle points, knobs, or circles can be inserted. The gem is then applied to the end of one of these tools, according to the nature of the cutting required, wetted with diamond-dust and olive oil, and by frequent working the subject is wrought. Frequent impressions are of course taken during the progress, to show the excesses or defects. These, however, are not necessary in working cameos, because the prominences are obvious to the eye. The tools are soft iron or copper; and the powder of the ruby, or other hard stones, is often substituted for diamond powder.

SEAL (A.-Sax. seol). In Zoology, the English name for a genus of Marine Carnivorous Mammiferous Quadrupeds, otherwise called *Phocidæ*. The variety of seals is very great, and they are found in great numbers in the seas round Spitzbergen, and on the coasts of Labrador and Newfoundland. The species (*Phoca vitulina*) which frequents the British shores is well known, and has been repeatedly described. Seals are principally hunted for their oil and skins. When taken in the spring of the year, at which time they are fattest, a full-grown seal will yield from eight to twelve gallons of oil, and a small one from four to five gallons. The oil, when extracted before putrefaction has commenced, is beautifully transparent, free from smell, and not unpleasant in its taste. The skin, when tanned, is extensively employed in the making of shoes; and when dressed with the hair on, serves for the covering of trunks, &c. The seals of the southern hemisphere have the fins better developed and more serviceable for motion on land than those of the northern hemisphere. [FISHERIES.]

Seal, Great. All charters, commissions, grants of land, franchise, liberties, &c., letters patent and letters close, of the king, pass the great seal. The course formerly was, that a grant, or letters patent, passed by bill; which was prepared by the attorney or solicitor general under warrant from the king. It was then subscribed at foot with the sign manual, and sealed with the privy signet. In this stage it was next, in some cases, taken directly to pass the great seal; in other cases, an

extract of the bill was taken to the keeper of the privy seal, who made out a writ or warrant thereupon to the chancery, where it passed the great seal. Thus the sign manual was a warrant to the privy seal, and that to the great seal. There were, however, some grants which only passed through certain offices, as the Admiralty or Treasury, under the sign manual, requiring neither privy nor great seal. By a recent act, however (stat. 14 & 15 Vict. c. 82), the practice of passing instruments under the great seal was simplified, and power given to the Lord Chancellor to make regulations with respect thereto. The custody of the great seal is now always entrusted to the Lord High Chancellor of Great Britain, that great officer being constituted by the mere delivery of the great seal into his hands, without patent or other formality.

In earlier times the offices of Lord Chancellor and of Lord Keeper of the great seal were occasionally distinct, but by 5 Eliz. c. 18 the keeper of the great seal has the same place and jurisdiction as the Lord Chancellor; since that statute, therefore, these offices cannot exist at the same time in different persons. The office of Lord Keeper has occasionally been revived in more recent times; the last Lord Keeper was Sir Robert (afterwards Lord) Henley, in 1757. When, as sometimes happens, the office of Lord Chancellor is put into commission, the great seal is entrusted to the chief commissioner. The seals of Scotland and Ireland are still in use for some purposes.

Seal, Privy. [SEAL, GREAT.] Some instruments of minor consequence pass the privy seal only. The keeper of the seal is now an officer of state, with the title of Lord Privy Seal. By 14 & 15 Vict. c. 82, the offices of clerks of the signet and privy seal were abolished.

Sealing-wax. The wax used for sealing letters, legal instruments, &c. The best *red* sealing-wax is made by melting in a very gentle heat 48 parts of shell-lac with 19 of Venice turpentine and 1 of Peruvian balsam; 32 parts of the finest cinnabar, thoroughly levigated, are then stirred in, and the whole well mixed. When it has cooled down, it is either rolled into sticks, or shaped in brass moulds. The best *black* sealing-wax is a mixture of 60 parts of shell-lac and 30 of ivory black: it may be perfumed with a little Peru balsam or styrax. The earliest application of sealing-wax to its present use seems to have been made about the year 1553. The first printed account of it is said by Berzelius to have appeared in 1563. The great seals applied in tin boxes to certain legal documents are made of a mixture of 15 parts Venice turpentine, 5 of olive oil, and 8 of wax melted together, and coloured with red lead.

Seaman. A man brought up to the sea, and capable of discharging the duties of that life. A complete seaman is called an *able seaman*, and is rated A.B.; one less competent, an *ordinary seaman*; and a man fresh from the shore, a *landsman* or ordinary seaman of the second class. The conditions upon which seamen are to be hired for merchant vessels, with their privileges and obligations, are regulated by the Merchant Shipping Act of 1854, &c. Wages are contingent on the success of the voyage; loss of a ship or capture by an enemy consequently exonerates the owners from liability for the wages of their seamen. For the Royal Navy the engagement of seamen takes place under the provisions of the Mutiny Act for the time being. The reader will find in the *Com. Dict.* full particulars respecting the enrolment, wages, and in short all the statistics of seamen.

Seams (Ger. saum). In a ship, the spaces between the edges of planks: these are caulked with oakum, and then covered with pitch.

SEAMS. In Geology, thin layers which separate thicker strata. Beds of coal are sometimes called *seams*.

Search, Right of, or more accurately of **Visit and Search.** In International Law, in time of war, right of search is defined to be the right of a belligerent to 'visit, to search, and to detain for search' every vessel, not being a ship of war, which he meets with on the ocean. It can be exercised only by a vessel commissioned by the authority of the state to which it belongs, whether man-of-war or privateer. The right of search in time of peace, to ascertain the nationality of a vessel, with a view to detecting piracy and slave trading, has been the subject of much controversy. (Phillimore, *International Law*, part x. ch. iii.)

Search Warrant. In Law, a warrant granted by a justice of the peace, to search for goods stolen, or respecting which other offences have been committed. The warrant is granted on the oath of a credible witness, that he has 'reasonable cause to suspect' the goods to be in the possession and on the premises of a certain individual (24 & 25 Vict. c. 96).

Seasons (Fr. saisons). The four quarters of the year—spring, summer, autumn, winter. The seasons are considered as beginning respectively when the sun enters the signs Aries, Cancer, Libra, and Capricorn; so that the *spring* season commences about the 21st of March, *summer* about the 22nd of June, *autumn* about the 23rd of September, and *winter* about the 23rd of December.

Sebaceous Glands (Lat. sebaceus, from sebum, *suet*). Small cuticular glands which secrete a greasy matter, serving to protect and soften the skin and cuticle.

Sebacic Acid (Lat. sebum). One of the acids produced during the destructive distillation of fat.

Sebestens. The dried fruits of *Cordia Myxa* and *C. latifolia*, which have long been used as a medicine in India.

Secale (Lat.). A genus of cereal grasses, to which belongs the Rye, *S. cereale*, a cornplant commonly cultivated for its nutritious grain, the flour of which forms an inferior kind

of bread. According to Karl Koch, Rye is found wild on the mountains of the Crimea, at an elevation of from 5,000 to 6,000 feet, its ears in such places being not more than from one to two and a half inches long. In this country it is the most limited of our corn crops.

The name of *S. cornutum* is sometimes given to Ergot of Rye, which is a black horn-like spur, into which the seeds or grains are changed as the result of disease. The same thing occurs in other grasses. In rye some of these spurs are as much as an inch in length, whilst in *Lolium* or Raygrass they seldom attain to half this size, and in smaller grasses the ergot is in proportion to the size of the seed. The Ergot of Rye has long been known as prevailing to a considerable extent in countries where rye is grown for bread, and some dreadful maladies are reported to have arisen where it has been ground with flour. Where it occurs amongst pasture grasses, its more immediate effect upon gravid animals appears to be the procuring of abortion; and as one of the commoner grasses, in which it occurs probably to a greater extent than in any other of our native species, is the *Lolium perenne*, which is always found to be largely mixed with all good pastures, it becomes a matter of importance to look well to a meadow in autumn before turning in cows, as there is too much reason to believe that abortion is somewhat frequent from a want of care in this respect. The quantity of ergot in almost any native species of grass growing in low damp meadows is quite astonishing; and even uplands are not without a considerable proportion if they have sufficient altitude to attract atmospheric vapours. Where and when it prevails there is much evidence to show that it is not advisable to depasture; but in cases of necessity the skimming over the bents with the scythe before the admission of cattle is a plan which might obviously be adopted with advantage. [ERGOT, ERGOTISM.]

Secant (Lat. seco, *I cut*). In Geometry, any right line which cuts a figure. A tangent is the limiting position of a secant when two points of intersection coincide. In Trigonometry, the *secant of an arc* is the line drawn from the centre of the circle through one of the extremities of the arc to meet the tangent at the other extremity. The *secant of an angle* is the reciprocal of the cosine.

Seceders. [BURGHERS.]

Secession (Lat. secessio, *a going aside*). In Politics, the act of a portion of a community (or, in common parlance, of a party in deliberative assemblies) who separate from connection with the remainder, and endeavour to form a body apart. The term had its first application in the instance of the alleged secession of the Roman plebeians to the Mons Sacer, as a protest against the usurpation of the patricians.

In modern times, it has come into popular use from a great recent example—the act of the so-called *Confederate* States in seceding from the American Union. The main argument used in favour of this proceeding was, that the constitution of 1787, while declaring that 'Each state retains its sovereignty, freedom, and independence,' contains no provision directly qualifying this doctrine by maintaining the inviolability of the Union; and that, consequently, the right of secession is implied in the term *sovereignty*; while the previous articles of confederation, superseded by the constitution, had contained the words 'the union shall be perpetual,' which it was reasonable to infer had been purposely abandoned. The answer ordinarily made was that the Union was in the nature of a league, implying mutual abandonment of rights in their very nature inconsistent with the existence of such union: and that there was no more occasion to prohibit, expressly, the repudiation by a state of the compact thus made, than to prohibit the *secession* of a county, a township, or an individual. See the argument on the Confederate side as stated by Mr. Spence, in his work on the American Union, 1862.

Sechium (a word coined from Gr. σηκίζω, *to fatten in a fold*). A genus of *Cucurbitaceæ*, represented by *S. edule*, the Chocho, commonly cultivated in the West Indian islands for the sake of its fruit, which is reckoned extremely wholesome, and is commonly used as an article of food by all classes. It has also the reputation of being a very fattening food for hogs and other animals. It is a climbing plant, with smooth stems rising from a very large fleshy root, which sometimes weighs as much as twenty pounds, and resembles a yam both in appearance and in its eatable qualities when cooked. The fruit is about four inches in length, oblong, between fleshy and succulent, sometimes furnished with small innocuous prickles, and either green or cream-coloured. The plant has been introduced into Madeira and other Atlantic islands, and from this source its fruits, called Chayotes, are sometimes sent to this country in a fresh state, and sold in Covent Garden Market.

Secle (Lat. sæculum, *an age*). In Chronology, a division of time. There were various secles; as the heroic secle, which consisted of 77 years [ROMULUS], the national secle, &c. [SOTHIAC PERIOD; TABULATION OF CHRONOLOGY.]

Second (Lat. secundus, *that which follows*, denoting the closest sequence). In Music, a musical interval; being the difference between any note and the next nearest, whether above or below it. It may be either major or minor. [MUSIC.]

SECOND. In the sexagesimal Arithmetic, the 60th part of a minute, or *prime*. Thus a degree of a circle, and an hour of time, are each divided into 60 minutes, and each minute into 60 seconds. In the old treatises on astronomy, the seconds are sometimes denominated *second minutes* (minutæ secundæ); while the minutes being the first divisions of the unit, are the *primes* (minutæ primæ). Following out the analogy, the sixtieth part of a second was called a *third*; but this term is not found in modern works. It was formerly usual to denote minutes

and seconds, both of time and arc, by the characters ′ and ″; but these are now generally, used only to indicate minutes and seconds of arc, those of time being indicated respectively by the abbreviations *m.* and *s.*

Second Coat. In Architecture, either the finishing coat, as in laid and set, or in rendered and set; or it is the floating when the plaster is roughed in, floated, and set for paper.

Second Sight (called in Gaelic taischitaraugh; from taisch, *an unreal* or *shadowy appearance*). A well-known Highland superstition. In all ages the idea has prevailed that persons endowed with the power of divination not only foretold by instinct, but had sometimes an actual and mysterious vision of distant or future events; as in the lines of Lucan, which describe the presages before the battle of Pharsalia:—

> Euganeo, si vera fides memorantibus, augur
> Colle sedens . . . .
> Venit summa dies, geritur res maxima, dixit:
> Impia concurrunt Pompeii et Cæsaris arma.

But the peculiarity of the Highland superstition seems to consist in this, that persons were supposed to be endowed with the faculty who were in no other respect feared or reverenced for their supernatural powers; it was regarded as a mere natural power, like superior sharpness of sight or hearing. The inhabitants of the Western Islands were thought to be peculiarly gifted with it. It could not be exerted at pleasure; the power came on the seer involuntarily, and often to his extreme terror and suffering. Nevertheless, certain rules were in fashion for the interpretation of the visions; such, for instance, as that mentioned by Sir W. Scott, that if a seer saw a figure with its back to him, and if on altering the position of his own plaid the figure appeared with its plaid similarly arranged, the vision regarded the seer himself. (See the superstition of the Bodach Glas, Scott's *Waverley*.) Martin, in his *Description of the Western Islands,* seems to have brought this superstition into notice in England. It is well known how Johnson undertook the defence of it, in his *Journey to the Western Islands*; but, in despite of evidence which neither Bacon, Boyle, nor Johnson were able to resist, the *taisch*, with all its visionary properties, seems to be now universally abandoned to the use of poetry. Campbell's beautiful poem of *Lochiel* will at once occur to the recollection of every reader. It is described by Collins in his ode on the *Superstitions of the Highlands.* But the classical bard of the second sight is Sir Walter Scott. (See especially his noble ballad *Lord Ronald*, the *Lady of the Lake,* the character of Allan Macaulay in the *Legend of Montrose,* &c.) Of belief in second sight at the present day, Mr. Logan, in his *Scottish Gael,* only says, 'It is not so prevalent as formerly.' (Vol. ii. 340.)

Secondaries. In Astronomy, this term denotes the satellites with regard to planets and the planets with regard to the sun, to distinguish them from their respective primaries. Thus, the moon is a secondary body with regard to the earth; the earth with regard to the sun, &c. [PLANET; SATELLITE.]

Secondary Circles. In Astronomy, secondary circles are great circles of the sphere perpendicular to another great circle, which is regarded as the primary, and they consequently pass through the poles of the sphere. The secondaries of the ecliptic are the circles on which the latitudes of celestial objects are measured.

Secondary Quills. (*Secondariæ*, Linn.) The large feathers of the wing which arise from the bones of the antibrachium or fore-arm, and principally from the ulna, are so called.

Secondary or **Mesozoic Rocks.** The great series of rocks occupying geologically the position intermediate between the Palæozoic and the Tertiary series. For an account of the rocks forming the group, see DESCRIPTIVE GEOLOGY.

The secondary series of rocks are admirably developed in England. Except the limestone near the base of the whole series [MUSCHELKALK], there is hardly a European secondary rock of the smallest importance that is not well and thoroughly represented in the British series, while many are with us exhibited in such interesting groups as to enable us to deduce a history of the period much more complete than can be learnt elsewhere. The oolites are especially rich in English geology, and pass upwards into the lower greensand [NEOCOMIAN] by the intervention of the Wealden, a deposit nearly wanting elsewhere, and not replaced by any important rock.

In consequence of this admirable developement, the English geologists have elevated the subdivisions of the series into an importance not warranted by what is known in European countries. In Asia and America, secondary rocks are still less important than on the mainland of Europe.

The secondary rocks include in England the best limestones for building purposes, but no marble properly so called. In the Alps, the rocks of this kind are much more metamorphosed, and exist on a far grander scale. The key to the complications of the Alpine system has, however, often been found by a close study of English rocks and their fossil contents.

The secondary rocks are extremely rich in fossils, and are remarkable for the number and variety of bones of reptiles found in them. The period has for this reason been called the Age of Reptiles. It is not less remarkable for the abundance and variety of cephalopodous molluscs, of which a vast number of groups exist, and which also seem to have been characteristic of the period. There can be little doubt that the unusual richness of the secondary period in organic remains is due to the fact that land was at no great distance from the localities where the rocks are best shown.

Secretary. An officer employed in writing letters, despatches, &c., under the orders of his superior. The title of secretary was first used to denote a public minister in France,

where the three clerks of the privy council were also termed secretaries, as early as the fourteenth century.

There are two secretaries of the navy, who are really the secretaries to the Board of Admiralty: of these one holds a permanent appointment, and the other is the parliamentary mouthpiece of the board, changing with the ministry. Each flag-officer also has a secretary to conduct his correspondence, the latter appointment being generally given to a paymaster or an assistant paymaster.

Secretary Bird. [GYPOGERANUS.]

Secretary, Lord. A high officer in the kingdom of Scotland, resembling the great prothonotary in foreign courts. This office was kept up after the Union, but has been disused since 1746.

Secretary of State. One of the highest officers of the British crown. This office, however, is comparatively modern in point of importance; the secretary of state having been originally what his name implies, a mere servant of the privy council. There was only one until the reign of Henry VIII., who added another; but their functions were limited to preparing business for the council board, which they attended afterwards with their proposals. Under Elizabeth, they became members of the council. Queen Anne raised the number to three, by the appointment of a secretary for Scotch affairs, an office which did not long continue; and one for the American department was appointed in the reign of George III., but abolished in 1782. At present there are five secretaries of state: for the Home Department; the Colonies; for Foreign Affairs; War; and India. In each of these departments there are two under-secretaries, one of whom remains in office on a change of ministry. The Alien Office is annexed to the Home Department. The State Paper Office belonged alike to the three first departments, until the recent changes of this department placed it under the control of the Master of the Rolls. [RECORD.] The secretary for home affairs has the custody of the privy signet; and the Privy Signet Office, in which grants, letters, &c., sealed with the privy signet, are made out, is in his department. The principal secretaries are always ex officio cabinet ministers. Their position in the English government is, in fact, identical with that of the ministers of home and foreign affairs, &c., in France and other Continental countries. Each of them may be said, in a general way, to have the management of all the executive business of his department, subject only to the duty of consulting his colleagues of the cabinet on matters which he deems of sufficient importance. But in any matter requiring advances from the funds at the disposal of the crown, whether British or Colonial, the secretary of state cannot act without the concurrence of the lords of the Treasury, except in the case of India, which has its separate financial administration. No rule prevails as to the selection of secretaries of state from the House of Lords or that of Commons. The secretary for Ireland is also keeper of the privy seal of that part of the kingdom, and chief secretary of the lord lieutenant. His office is divided into two departments, military and civil, in each of which an under-secretary is placed; he is sometimes a member of the cabinet.

Secretion (Lat. secretio). The process by which substances are separated from the blood in animals, or from the sap of vegetables.

In some cases a secretion appears to be a mere separation of water, and of other substances held in solution by it, from the blood; but in others the process is much more elaborate and intricate. A highly complicated glandular structure is requisite; and the proximate or ultimate elements of the blood are arranged into new combinations, so as to constitute a new and distinct product, of which no traces are to be found in the healthy blood. The animal secretions are arranged by Bostock under the heads aqueous, albuminous, mucous, gelatinous, fibrinous, oleaginous, resinous, and saline. Magendie's classification of the secretions comprises, 1. Exhalations, as from the skin, the surfaces of the closed cavities of the body, and the lungs; 2. Follicular secretions, which are either cutaneous or mucous, and, 3. Glandular secretions, such as milk, bile, urine, saliva, &c. [BOTANY; PHYSIOLOGY; &c.]

SECRETION. In Botany, this term is applied to any organic but unorganised substance produced in the interior of plants.

Sect (Lat. secta). A term used in ordinary language to signify any body which separates from the established religion of a country; originally the term was applied to the *followers* of some distinguished person, and seems to be derived from Lat. sequor, *I follow*. The chief sects, both of philosophers and religions, will be found noticed under their respective heads.

Sectile (Lat. sectilis, *that may be cleft*). In Botany, a term applied to bodies which are cut into small pieces, as the pollen masses of some orchids.

Section (Lat. sectio, from seco, *I cut*). The projection or geometrical representation of a building or other object, supposed to be cut through, so as to exhibit its interior configuration.

SECTION. In applied Geometry, the *surface* formed when a solid is cut by a plane. In the theory of surfaces, the term section is applied to the curve in which one surface is cut by another. Thus, the *plane section* of a plane is a right line, while that of a sphere is a circle. The plane sections of a cone are termed CONIC SECTIONS. In general the section of a surface of the m^{th}, by another of the n^{th} order is a curve of double curvature of the mn^{th} order, i.e. a curve which is cut by a plane in mn points. [CURVE.]

The name *angular sections* was given by Vieta to that branch of analysis in which the trigonometrical functions of multiples

and submultiples of an angle are investigated. Euler, Lagrange, Poinsot, and many others, have written on this subject; their results are now incorporated in every good treatise on plane trigonometry.

Section of a Ratio and *Section of a Space* are terms employed by Apollonius of Perga, who wrote two books with those titles; the former of these terms was restored by Dr. Halley, and the latter by Willebrord Snell.

Sections. In Shipbuilding, vertical planes at right angles to the keel, taken at any part of a vessel's length to assist the builder. The *body-plan* represents a collection of these sections developed on the largest of them all, the midship section.

Sector (Lat.). In Astronomy, an instrument constructed for the purpose of determining with great accuracy the zenith distances of stars passing within a few degrees of the zenith, where the effect of refraction is small. [ZENITH SECTOR.]

SECTOR. In Geometry, the *sector of a circle* is the figure bounded by two radii and the intercepted arc. Sectors of different circles are said to be *similar* when the sides or radii include equal angles. The area of a sector is equal to that of a triangle whose base is equal to the length of the contained arc, and whose altitude is equal to the radius of the circle.

SECTOR. A mathematical instrument, of considerable use in making diagrams, laying down plans, &c. Its principal advantage consists in the facility with which it gives a graphical determination of proportional quantities; and hence it is called by the French *the compass of proportion.*

The sector may be used in trigonometry for obtaining a rough solution of all the cases of right-angled plane triangles; and it is also conveniently applied to the construction of various geometrical problems. For a description of the instrument and of its different uses, see Robertson's *Treatise of such Mathematical Instruments as are usually put into a Portable Case.*

Sectoral Barometer. An instrument, invented by Magellan, in which the height of the mercurial column is found by the angle at which it is necessary to incline the tube in order to bring the mercury to a certain mark on the instrument.

Secular (Lat. sæcularis, from sæculum). The Latin word sæculum, besides the meaning of a century or generation of mankind, had that of a number, or race—*sæcla ferarum* (Lucret.), and was also used to signify the fashion of the time, or the *age*, as we should now say—corrumpere et corrumpi, sæculum vocatur (Tacitus). Hence, Christian writers came to employ it in the sense of *the world*, in opposition to the *church*. And thus, again, in still later times, the *secular clergy*, i.e. the parochial priesthood, engaged about the affairs of the world, were opposed to the *regular*, i.e. clergy belonging to religious orders who lived under *rule*. Hence, in Politics, the appropriation of religious property to non-religious uses is termed *secularisation*. This took place, in England, by the gradual absorption of tithes belonging to the church by lay incumbents; and on a large scale by the measures of Henry VIII. at the Reformation. In most Continental states, secularisation of church property has taken place on a larger scale than among ourselves. [MONACHISM.]

Secular Equation, Secular Inequality. In Astronomy, any deviation from the mean motion or mean orbit of a celestial body is called an *inequality*, and the numerical expression of the magnitude and period of the inequality is called an *equation*. The equations representing the motions of the bodies of the solar system are of two kinds, *periodic* and *secular*: the first being those which pass through all their changes and return to the same state in a comparatively short period of time; and the second such as change their value so slowly that the variation becomes sensible only after the lapse of centuries, and require for the accomplishment of the series of their changes a length of time which in some cases astronomers have not yet ventured to calculate. Thus the lunar *evection*, which depends on the position of the transverse axis of the moon's orbit in respect of the line of the syzygies, is a *periodic* inequality, passing through all its different values in about 31 days 19¼ hours; but the acceleration of the moon's mean motion, depending on a slow variation of the eccentricity of the earth's orbit, is a *secular* inequality, amounting only to about 10 seconds in a century. The secular inequalities are, in fact, periodic as well as the others; but they proceed so slowly that the observations of many hundreds, or even thousands of years, would be insufficient to make known their periodicity. The discovery of their true nature is one of the results of the theory of gravitation.

Secular Games. In Roman Antiquities, games celebrated once in each sæculum. They lasted three days and three nights, during which time sacrifices were offered up, and theatrical shows exhibited, and combats in the circus, &c., took place. Valerius Publicola, the first alleged consul created after the expulsion of the kings, is said to have been the first who celebrated them at Rome. Some authors maintain that the *sæculum*, or age, consisted of 100, and others of 110 years; but several Roman emperors did not allow so long an interval as either period to elapse. Thus, Augustus celebrated secular games A.U. 736, Caligula 64 years later, and Domitian 26 years afterwards. According to Zosimus, the emperor Septimius Severus was the last who celebrated them; but other writers have stated that under the emperor Philip, A.U. 1000, these games were held with more magnificence than had ever been before witnessed. (Gibbon's *Roman Empire*, ch. vii.) They were celebrated, in all, eight times.

The original sæculum of the Etruscan augurs

is said by some to have been measured by the longest life of those who were born at its commencement; and they had a tradition, that the duration allotted to nations was measured by a certain number of these sæcula. (Plutarch, *Sulla*; Censorinus, *De Die Natali*.)

Secular Poems. Poems recited at the celebration of the SECULAR GAMES. Of this species of poem, the secular Sapphic Ode of Horace is a noble specimen.

Secular Refrigeration. The periodical cooling and consequent consolidation of the crust of the globe: a term formerly used by geologists in reference to the supposed central heat, and even fluidity of the globe, and to the phenomena of its gradual refrigeration.

Secular Year. [JUBILEE.]

Secularisation. [SECULAR.]

Secund (Lat. secundus, *next in the same rank*). In Botany, this term is applied when all the flowers or leaves or other organs of a plant are turned towards the same side.

Secundine. In Botany, the outermost but one of the enclosing sacs of the ovulum, immediately reposing upon the primine. Mirbel considers it the second integument formed by the ovule; Schleider says it is the first, and that the primine or first integument of Mirbel is formed afterwards.

Secundines. In Zoology, the fœtal membranes collectively are sometimes so termed.

Secures. [FASCES.]

Securidaca (Lat. securis, *a hatchet*). A genus of *Polygalaceæ*, chiefly inhabiting tropical America. The Buaze fibre plant, spoken of by Dr. Livingstone, is *S. pallida*. It is a bush of from four to eighteen feet high, with pale green leaves, and small dingy purple flowers, and grows in rocky places at the foot of hills near the Zambesi and Shire Rivers, as well as in Mozambique. The twigs are cut by the natives in January and February for the sake of the fibre, of which they make cord, fishing-nets, &c. The fibre resembles flax. Many of the South American species ramble to a great height over other trees, and are beautiful objects when in flower.

Securifers (Lat. securifer, from securis, *a hatchet*, and fero, *I bear*). The name of a tribe of *Terebrantia*, or boring Hymenopterous insects, comprising those in which the females have a saw-shaped or hatchet-shaped terebra or appendage to the posterior part of the abdomen for the purpose of preparing a place to receive the eggs, and of depositing them therein.

Securipalps (Lat. securis, *a hatchet*; palpo, *I touch softly*). The name of a family of Coleopterous insects, comprehending those in which the maxillary palps terminate in a joint which is elongated and hatchet-shaped.

Secutores (Lat. *followers*). A name supposed by some to have been given to GLADIATORS, who followed the retiarius, when he had failed to secure his antagonist with the net. By others, they are supposed to be the suppositii, i.e. those who followed or were put in the place of gladiators already slaughtered.

Sedatives (Lat. sedo, *I calm*). Medicines which assuage pain; generally by inducing sleep and diminishing irritability.

Sedentaries. The name of a section of spiders (*Araneidæ*), comprehending those which remain motionless in the hiding-place of their web until called forth by an entangled prey.

Sederunt (Lat.). A term used in Scotland in the minutes of courts and other bodies, meaning that '*they* (naming the members) *sate* on such a day': hence applied to mean a *sitting* of such court or body.

Sedge (A.-Sax. secg). The common name for *Carex*. What is called Sweet Sedge is the *Acorus Calamus*.

Sedge Bird. The name of the *Sylvia phragmitis*, Bech. This species of warbler visits this country about the middle of April, and emigrates in September. It frequents the sedgy banks of rivers, and constructs a nest composed of a little moss intermixed with dry stalks, lined with dry grass, and occasionally a few hairs. It lays five or six eggs of a light brown colour, mottled with darker shades of the same. It is sometimes called *reed bunting*.

Sediment Collectors or **Scale Pans.** Vessels suspended in a boiler, for collecting the portions of the sediment which are brought to the surface by the bubbles of steam. These portions would otherwise settle to the bottom of the boiler or on the flues, and form scale. Sediment collectors are not now much used, but the sediment which is ballooned to the surface is blown out at once.

Sedition (Lat. seditio). In Law, a general and not strictly technical word, comprising, in common language, offences against the state which do not amount to high treason. The distinction betweeen the two offences was not very accurately adhered to or defined until later times. Sedition is of the like tendency with treason, but without the *overt acts* which are essential to the latter. Thus, there are seditious assemblies, seditious libels, &c., as well as direct or indirect threats and acts amounting to sedition; all punishable as misdemeanours.

Seduction (Lat. seductio, a *leading aside*). In English Jurisprudence, seduction is regarded as ground for civil action only, brought by the father of the injured person on the technical ground that he has lost, by reason of the wrong thus done, the benefit of the service of the injured party. Being grounded on this fiction, the action is maintainable by a master on behalf of his female servant.

Sedum (Lat. *a house-leek*). This genus of Crassulaceous plants is remarkable for its succulent leaves, and terminal cymes of yellow, white, or purple flowers. The structure of *Sedums* is such as to enable them to vegetate for a long time without absorbing moisture from the earth. There are several British species, the most common of which, *S. acre*, the Stonecrop, is a low plant with tangled stems, short fleshy leaves (which are produced into a kind of spur at the base), and golden yellow flowers.

See (Lat. sedes, *a seat*). The name usually given to the diocese of a bishop. It was originally applied exclusively to the papal chair at Rome; but it has long been used in its present wide signification.

Seed (A.-Sax. sæd, Ger. saat). In Botany, the reproductive part of a plant resulting from impregnation, and containing the embryo or rudiment of a future plant. In other words, it is the ovule in its most perfect and finally organised state. It is a form of reproductive matter peculiar to flowering plants, its equivalent in flowerless plants being the spore. It is commonly said that as the seed is the part intended by nature to multiply the races of plants, special contrivances are provided for insuring its dispersion and migration from place to place; such, for instance, as being discharged with force by the sudden explosion of the case or seed-vessel in which it is generated, having membranous wings that render it buoyant, and so on. But this idea, although to a certain extent true, is frequently misapplied to seed-vessels, as in the instance of the Dandelion, the Ash-tree, the Sycamore, &c.: in these latter cases the part to which the name of seed is given is a true pericarp or seed-vessel. On the other hand, many kinds of seed-vessels, such, for instance, as those of corn, of labiate and boraginaceous plants, &c., are miscalled seeds, or naked seeds.

Seed Lac. [Lac.]

Seed Pearl. [Pearl.]

Seg. An East Anglian form of the word *sedge*, applied to rushes, reeds, and sedges. The name Segg is applied in some parts of the country to the common Flag, *Iris Pseudacorus.*

Seggars. [Porcelain.]

Segment (Lat. segmentum, *a part cut off*). In Geometry, any part cut off from a figure. Thus, the *segment of a line* is the part which lies between two of its points. The *segment of a circle* is the part cut off by a chord. *The segment of a sphere* is the part cut off by any plane, &c. The *angle of a segment*, in the case of a circle, is the inclination of the arc to the chord; in the case of a sphere, it is the inclination of the spherical surface to the plane. Segments whose angles are equal are said to be *similar*. The area of a circular segment is found by deducting from the area of the corresponding sector that of the triangle whose base is the chord. With respect to the superficial area and the volume of a spherical segment, see Sphere.

Segment Shell. In Artillery, an elongated shell, invented by Sir W. Armstrong. It consists of a body of iron coated with lead; inside the body a number of segments of iron are built up in successive rings, leaving a hollow cylinder in the centre for the bursting charge. On the explosion of this bursting charge the segments are scattered; but, on the principle of the arch, they strengthen the shell and prevent its being broken by any external blow: and so the projectile can be used as solid shot. It may also be used as case, by regulating the fuze so as to burst the shell on leaving the muzzle.

Segno (Ital. *a mark*, Lat. signum). In Music. [Al Segno.]

Segregation (Lat. segregatio, *a separating*). That process in nature by which, when a mixed mineral mass has been deposited or accumulated and left to the influence of the chemical forces always operating, certain minerals tend to separate themselves from the mass and collect into natural cracks or blisters either previously existing or formed during the operation. It sometimes happens that instead of occupying cracks or blebs the separating part forms belts or bands. Calcareous rock separates in this way from clay, and many volcanic minerals from lava.

Segue (Ital. *it follows*). In Music, a word which, prefixed to a part, denotes that it is immediately to follow the last note of the preceding movement. When minims, crotchets, &c., are subdivided by a stroke drawn through their tails, so as to make them into abbreviated groups, the term indicates that the following notes are divided similarly to those first marked.

Seguiera (after J. F. Sequier). A genus of *Petiveriaceæ*, comprising a few South American shrubs, smelling more or less strongly of garlic or assafœtida; the whole plant, root, wood, and herbaceous parts, having this powerful odour. On this account, baths impregnated with *S. alliacea* are in repute in Brazil in cases of rheumatism, dropsy, and hæmorrhoidal affections. The wood abounds in potash, and the ashes are employed in clarifying sugar, and in soapmaking in Brazil.

Seicentisti (Ital.). In Literary History, the Italian writers of the seventeenth century. As these stood lower than the writers of the latter part of the preceding century, who had themselves declined from the earlier standard, the name became associated with the idea of false taste and expression. (Hallam, *Literary History*, part iii. ch. v. § 1.)

Seidlitz Water. The mineral water of Seidlitz, a village of Bohemia: sulphate of magnesia, sulphate of soda, and carbonic acid, are its active ingredients. It is often taken as an agreeable and effective aperient. The article sold under the name of *Seidlitz powders* is intended to produce the same effect, though very different in composition. These powders are generally sold in different coloured papers: one blue, containing 2 drachms of the potassa-tartrate of soda mixed with 2 scruples of bicarbonate of soda; the other red, containing 35 grains of finely powdered tartaric acid. The former powder is dissolved in half a pint of water, and the latter in a separate wine-glassfull; the solutions are then mixed, and taken in the act of effervescence.

Seigniory (Fr. seigneurie). In Feudal Law, a manor or other lordship.

Seignorage. In Finance, the charge levied by government to cover the expense of coinage, or to serve as a fund from which public income

may be derived. The seignorage, if levied at all, must not be too high, else it affords an almost irresistible temptation to private coining, and as it must be high in order to form any important branch of revenue, it is generally no more than is thought sufficient to cover the cost of minting. The effect of a seignorage is to make coin more valuable than bullion.

In this country no fixed seignorage is levied on gold, which is the standard of value. Any person may have standard gold coined in quantities of not less than 10,000*l*., at the public cost. The short delay, indeed, during which the manufacture takes place would amount by the interest on the specie to a slight seignorage; but as the coinage is carried on through the agency of the Bank of England, and no private person can employ the agency of the mint for obtaining sovereigns, the loss is not really incurred, and such a seignorage as might affect the private individual does not take effect on the Bank issues of coin. In France, however, coin is worth more than bullion, by reason of the seignorage, and when monetary transactions take place between this country and France, coin must be treated as bullion. The absence of uniformity in the monetary systems of Europe is, irrespective of the weights of the several denominations, a serious hindrance and loss in international trade, and an inconvenience which calls urgently for a reform based on a mutual understanding. No greater advantage could be given to nations, and none could more fully serve the purpose of uniting them by common interests, than an intelligible system of mutual and easily adjusted currencies.

A considerable seignorage is levied on the silver and copper currencies in this country. But this does not in the least degree affect values. Neither are legal tenders in anything but small amounts, and both are an exclusively local currency, since the exportation of silver coin at its nominal value would entail a loss of upwards of 8, the exportation of copper coin fully, on an average, a loss of 100 per cent. [CURRENCY; MONEY.]

Seirens (Gr. Σειρῆνες). In Greek Mythology, beings who so charmed mariners by the sweetness of their song, that they steered their ships to the spot from which the sweet sounds came, and were lost among the breakers. When ODYSSEUS was returning home from Troy, the wise Kirkê (Circe) told him that he could avoid the danger only by stuffing the ears of all his sailors as well as his own with wax, as long as they remained within hearing of their voices. Odysseus followed this advice strictly in the case of his sailors; but, wishing to hear the song, he left his own ears unstopped, and had himself lashed to the mast. His entreaties to be loosed were thus disregarded by the sailors, who could not hear the songs which charmed Odysseus.

This legend has been applied by many to show that the poet designed to convey a moral lesson on the enticements of evil pleasures, and to exhibit in Odysseus an example of firm resistance to temptation; but the incidents just related completely overthrow such a supposition.

According to the *Odyssey*, the island of the Seirens lay between Æaea and the rock of SCYLLA; but that poem does not mention their numbers. Later myths not only define their number, but specify their names, while they also vary in the accounts given of their abodes.

Seisachtheia (Gr. σεισάχθεια, literally *a shaking-off of burdens*). The disburdening ordinance which formed the first step in the legislature of Solon. The Solonian poems prove the extreme misery and degradation of the poorer Attic freemen under the existing laws of debt. These evils had risen to such a height that the laws could no longer be enforced, and Solon, it is said, resolved on a measure which should completely extirpate them. His seisachtheia, in Mr. Grote's words, 'cancelled at once all those contracts, in which the debtor had borrowed on the security either of his person or of his land; it forbad all future losses or contracts in which the person of the debtor was pledged as security; it deprived the creditor in future of all power to imprison, or enslave, or extort work from his debtor, and confined him to an effective judgment at law authorising the seizure of the property of the latter.' (*History of Greece*, part ii. ch. xi.)

On the purport and extent of this ordinance many opinions have been entertained. While some ancient writers regarded it as having cancelled all money contracts, others held that it simply lowered the rate of interest and depreciated the currency, leaving the letter of the contracts untouched. The latter notion seems to be refuted by the Solonian fragments, while the debasement of the coinage disproves the former supposition, for with the rescinding of all contracts the need of any debasement is at once removed. It cannot, however, be maintained that the relief so given involved injustice to none, for the creditors were unquestionably deprived of money or gains to which they were legally entitled; but the measure, as Mr. Grote urges, is to be vindicated 'by showing that in no other way could the bonds of government have been held together, or the misery of the multitude alleviated. We are to consider, first, the great personal cruelty of the pre-existing contracts which condemned the body of the free debtor and his family to slavery; next, the profound detestation created by such a system in the large mass of the poor against both the judges and the creditors by whom it had been enforced. . . . Moreover, the law which vests a creditor with power over the person of his debtor, so as to convert him into a slave, is likely to give rise to a class of loans which inspire nothing but abhorrence—money lent with the foreknowledge that the borrower will be unable to repay it, but also in the conviction that the value of his person as a slave will make good the loss, thus reducing him to a condition of extreme misery, for the purpose

sometimes of aggrandising, sometimes of enriching the lender. Now, the foundation on which the respect for contracts rests, under a good law of debtor and creditor, is the very reverse of this. It rests on the firm conviction that such contracts are advantageous to both parties as a class, and that to break up the confidence essential to their existence would produce extensive mischief throughout all society.' And, finally, it must be remembered that this measure settled the question to which it referred. In striking contrast to the agitation of Roman society arising from the same evils, the law of debtor and creditor never again disturbed the peace of Athenian citizens.

Seisin. In the Law of England, seisin signifies the feudal possession of land.

Seisin, Livery of. The formal delivery of the possession of land, formerly essential to its transfer, but now disused.

Seismology. [EARTHQUAKES.]

Seismometer (Gr. σεισμός, *an earthquake*, and μέτρον). An instrument for measuring the shock of earthquakes and other concussions.

Sejant. In Heraldry, a term employed to describe beasts when represented in a sitting posture. *Sejant-rampant*, sitting with the two fore feet lifted up, &c.

Selacians (Gr. σέλαχος). The name given by Cuvier to the tribe of Chondropterygians which includes the rays and sharks.

Selaginaceæ (Selago, one of the genera). A small order of Perigynous Exogens, agreeing with *Verbenaceæ* in their irregular flowers, two or four stamens, and free two-celled ovary not lobed, with one ovule in each cell; but differing from that order, as well as from the closely allied *Myoporaceæ*, in the anthers being always one-celled only. They are all herbs or small shrubs, and chiefly from Southern Africa. *Selago* itself, the typical genus, contains upwards of seventy species, herbs or undershrubs, with small entire somewhat alternate leaves, and sessile spiked two-lipped flowers.

Selaginella. This genus of *Lycopodiaceæ*, the largest in the order, is distinguished from *Lycopodium* by its flat two-ranked stem, and its two forms of two to three valved fruit, one of which contains large pallid spores, the other free spore-like orange or scarlet antheridia, which at length produce spiral spermatozoids. The species vary greatly in size, some being minute, resembling the larger *Jungermanniaceæ*, while others attain a considerable size. The leaves, which sometimes assume a bluish tint, are generally of different sizes. The numerous species are inhabitants of warm regions, and frequently, being extremely elegant, are favourite objects of cultivation. *S. convoluta* has the fronds curiously curled in and contracted when dry, so as to form a ball like the Rose of Jericho, which expands when moistened. *S. mutabilis* has the remarkable property of changing its colour every day, being in the morning of a bright-green, but as the day advances becoming gradually pale, and at night resuming its deeper tint.

Selbite. A massive mineral of an ash-grey to a black colour, and very soft, found at Altwolfach in Baden, and in Mexico. It is composed of carbonate of silver with about 15 per cent. of carbonate of antimony with oxide of copper; but, probably, it is only a mechanical mixture. Named after Selb, by whom it was analysed.

Selene (Gr. *the moon*). In the Hesiodic *Theogony* (371), a daughter of HYPERION and Theia, and a sister of Helios and Eos. Selene is the lover of ENDYMION, the sinking sun; and she was also known as Asterodia, the wanderer among the stars. These words displayed their meaning to the Greek in his own language, and hence the original idea was more clearly retained than in legends which grew up about names that had lost their significance, as in the myth of Argynnis (the beloved of Agamemnon), which in Sanscrit is *Arjuni*, a mere epithet denoting the brilliancy of the morning.

Selenite (Gr. Σεληνίτης). The name generally applied to transparent crystallised Gypsum. It is a hydrated sulphate of lime, and generally occurs in flattish, white, transparent crystals, which are easily susceptible of cleavage into thin laminæ that are flexible but not elastic. Selenite is found in many places; generally in clay, as in the London clay of London and Surrey, and of Walton-on-the-Naze in Essex; in the Eocene clays of the Isle of Wight, in Alum Bay, &c.; in the Oxford clay of Shotover Hill, Oxfordshire; in the Lias of Gloucestershire, the Gault of Folkestone, &c.

Selenium (Gr. Σελήνη, *the moon*). A substance discovered in 1818 by Berzelius. In its general chemical habitudes it bears a resemblance to sulphur. It has hitherto been obtained in very small quantity, and generally occurs in some of the varieties of iron pyrites. It is a brittle opaque substance, tasteless, and inodorous; having something of the appearance of lead, but of a deep red colour when reduced to powder. Its specific gravity is about 4·3. At 212° it becomes soft and tenacious, and at 220° is perfectly liquid; at 650° it boils and sublimes. It is insoluble in water, and unaltered by air; and when heated by the blowpipe, so as to become oxidised, it exhales a strong odour of horse-radish. Its equivalent is about 40. It forms an oxide and two acids; the *selenious acid* being a compound of 1 equivalent of selenium and 2 of oxygen, and the *selenic acid* of 1 and 3. It also combines with hydrogen, forming the *hydroselenic acid*, a gaseous compound of 40 selenium + 1 hydrogen. Its odour at first resembles sulphuretted hydrogen, but afterwards it powerfully irritates the nose, excites catarrhal symptoms, and destroys the sense of smell. Dr. Prout has suggested the possibility of the evolution of this compound by volcanoes, and its diffusion through the atmosphere as productive of certain forms of the epidemic disorder called influenza.

Selenography (Gr. Σελήνη, and γράφω, *I describe*). The description of the surface of

the moon, as geography is a description of the surface of the earth.

Seleucidæ, Era of the. In Chronology, the era of the Seleucidæ, otherwise called the Macedonian era, dates from the epoch of the first conquests of Seleucus Nicator in Syria, about 311 years B.C. It was followed generally by the Greek colonies bordering on the Levant; and by the Jews till the fifteenth century, by whom it was called the *era of contracts*. There is considerable difference of opinion among authors respecting the month and day on which the year of this era commenced, so that it is frequently not possible to fix the correspondence of dates; but, according to the computation most generally followed, the year 312 of the era of the Seleucidæ began on September 1 in the Julian year preceding the first year of our era. Hence, to reduce a Macedonian date to the common era, subtract 311 years and 4 months.

Self-conjugate Triangle. [CONJUGATE TRIANGLE.]

Sella Turcica. A cavity in the *sphenoid* bone; it is surrounded by the four clenoid processes, and contains the pituitary gland.

Selli. The priests of ZEUS, who delivered his oracles at the sacred grove of Dodona in Thessaly. (Gladstone's *Homer and the Homeric Age*, i. 108.)

Selters or **Seltzer Water.** A mineral water from Seltzer, about ten miles from Frankfort-on-the-Maine. It is an agreeable beverage, from the quantity of free carbonic acid which it contains, and which covers its slightly saline taste. Common salt, with the carbonates of magnesia, lime, and soda, are the saline ingredients. [MINERAL WATERS.]

Selvage or **Selvagee.** A piece of very flexible rope, composed of yarns not twisted together, but laid parallel, and confined externally by marline.

Semaphore (Gr. σῆμα, *a sign*, and φέρω, *I bear*). A term mostly used synonymously with *telegraph*, but which, as its derivation imports, may be applied to any means employed to communicate intelligence by signals. [TELEGRAPH.]

Semé (Fr. *sown*). In Heraldry, a term employed to describe a field or charge powdered or strewed over with figures, such as stars, billets, crosses, &c.

Semecarpus. A genus of Indian trees belonging to the *Anacardiaceæ*, one species, *S. Anacardium*, being the Marking-nut tree of India. The thick fleshy receptacle bearing this fruit is of a yellow colour when ripe, and is roasted and eaten by the natives. The unripe fruit is employed for making a kind of ink, and when pounded serves to form a kind of birdlime. The hard shell is permeated by an acrid corrosive juice, which is employed externally in rheumatic affections, as well as for destroying warts, but its acridity sometimes causes much inflammatory swelling. This juice, when mixed with quicklime, is employed to mark cotton or linen with an indelible mark. When dry, it forms a black varnish, much used in India; and amongst other purposes it is employed, mixed with pitch and tar, in the caulking of ships. The seeds, called Malacca-beans or Marsh-nuts, are eaten, and are said to stimulate the mental powers. From them an oil is procured, which is used in painting.

Semeiotic (Gr. σημειωτικός, from σημεῖον, *a sign*). That which relates to the signs or symptoms of diseases.

Semelê (Gr.). In Greek Mythology, a daughter of Cadmus and Harmonia, and sister of Agavê. [PENTHEUS.] In the Theban legend, she was beloved by Zeus; and Hera, moved by jealousy, appeared before her in the form of her nurse Beroe, and incited her to demand from Zeus a manifestation of his splendour when next he came to visit her. Zeus, being already under promise to give whatever she might ask, granted her prayer; and Semelê was accordingly scorched by the lightnings, while Dionysus, her child, was born amidst the flames. The Laconian version relates that, after giving birth to Dionysus, she was (like Danaê, the mother of PERSEUS) cast forth in a boat, and that her body was thrown up lifeless on the coast near Brasiæ, where Dionysus was brought up.

Semen Contra (Lat.). The Pharmaceutical name for a drug composed of the dried leaves and flower-heads of *Artemisia Sieberi*, and some allied species. It is a celebrated vermifuge. *Semen cinæ*, or *Semencine*, is a drug of similar character, obtained from several species of the same genus.

Semi-Arians. A branch of the Arians, who denied the ὁμοούσιον, or *consubstantiality* of the Son with the Father; but admitted the ὁμοιούσιον, or *similarity of substance*. [ARIANS; HOMOOUSIANS.]

Semi-cubical Parabola. [PARABOLA, SEMI-CUBICAL.]

Semi-Pelagians. The Semi-Pelagians differ from the PELAGIANS in maintaining the necessity of the divine grace towards the practice of virtue; but at the same time conceive that this grace may be obtained by an effort of the human will. (Milman's *Latin Christianity*, book ii. chap. ii.)

Semi-regular Polyhedrons. [POLYHEDRON.]

Semibreve. In Music, a note whose length is half that of a breve. It is the longest note generally used in modern music, and is the integer whose fractions are usually adopted to express the length of other notes.

Semicircle. In Geometry, the half of a circle; or the figure bounded by the diameter and half the circumference.

Semicolon. [PUNCTUATION.]

Semidiameter. In Geometry, half of the diameter; or the part of the diameter of any figure comprehended between the centre and the extremity of the diameter.

Semimetal. A term applied by the old chemists to the brittle metals.

Seminary (Fr. séminaire). In the language of the Roman Catholic Church, an esta-

blishment for the maintenance of missionaries intended to be employed in the conversion of infidels and heretics. The chief of all seminaries is that at Rome, entitled also the Apostolical College, but best known under the title of the Seminary or College 'for the Propagation of the Faith.' It was founded by Pope Urban VIII., through the exertions, chiefly, of a Spanish ecclesiastic, Juan-Baptista Virès, of Valencia, in the first half of the seventeenth century. The 'Seminarists' maintained in this establishment are afterwards employed under the direction of the Congregation of Cardinals for the propagation of the faith; as are those of various minor colleges established in Rome for the benefit of particular nations and races. The word *seminary* has since passed into ordinary use for a variety of educational establishments for the clerical order. In France the greater or diocesan seminaries are collegiate institutions; the little seminaries are secondary schools; and all are under the special superintendence of the episcopal authorities.

Seminvariant. The coefficient of the highest power of one of the facients in the covariant of a quantic. Thus the quadri-covariant quartic or Hessian of the binary quartic

$$(a_0, a_1, a_2, a_3, a_4 \between x, y)^4$$

being

$$(a_0a_2 - a_1^2,\ 2a_0a_3 - 2a_1a_2,\ a_0a_4 + 2a_1a_3 - 3a_2^2,\ 2a_1a_4 - 2a_2a_3,\ a_2a_4 - a_3^2 \between x, y)^4,$$

$a_0a_2 - a_1^2$ is a *seminvariant* of that quartic, as also is $a_2a_4 - a_3^2$. To understand the appropriateness of the term, it must be remembered that, according to Prof. Cayley's definition, an invariant is any function of the coefficients of a quantic which is reduced to zero by *each* of the operators which, for the original quantic, are equivalent to $y\frac{d}{dx}$ and $x\frac{d}{dy}$. [INVARIANT.] Now, a seminvariant is reduced to zero by *one*, but not by the other, of these operators. (Salmon's *Higher Algebra*, p. 75.) In the above case, these operators are

$$a_0\frac{d}{da_1} + 2a_1\frac{d}{da_2} + 3a_2\frac{d}{da_3} + 4a_3\frac{d}{da_4}$$

and

$$a_4\frac{d}{da_3} + 2a_3\frac{d}{da_2} + 3a_2\frac{d}{da_1} + 4a_1\frac{d}{da_0}$$

respectively. These functions were originally termed *peninvariants* by Brioschi; the more appropriate term *seminvariant* appears to have been proposed by Cayley.

Seminymph. Lyonnet so calls the nymphs of those insects which undergo but slight changes in passing to the perfect or imago stage.

Semiopal. A silicious mineral, nearly resembling the Common Opal, but differing from it in being harder and more opaque, in exhibiting a less perfect conchoidal fracture, and in the muddiness of its colours. It is found at Okehampton in Devonshire, and in Cornwall at Huel Buller and near St. Ives and St. Just.

Semipalmate (Lat. semi, *half*, and palma *a palm*). In Zoology, when the toes are connected together by a web extending along only their proximal half. The term *semi* being frequently used in the composition of zoological terms with the same meaning, it is only requisite to refer to the term to which it is prefixed.

Semiquadrate or **Semiquartile.** In the language of Astrology, an aspect of the planets when distant from each other half a right angle, or 45°. The terms *semiquintile* and *semisextile* have a similar meaning; the first denoting the *half of a fifth* of the complete circle, that is, 36°; and the second the *half of a sixth*, or 30°.

Semiquaver. In Music, a note whose duration is half that of a quaver.

Semiramis and **Ninus.** In Mythology, the founders of the Assyrian Empire of Nineveh. According to Herodotus (i. 184), Semiramis reigned five generations before Nitocris, whom he represents as the wife of Labynetus, the father of the king of the same name who was reigning at Babylon when it was taken by Cyrus. According to Ctesias, she was the wife of Ninus, from whom Nineveh received its name. In the chronology of Berosus, she follows a series of dynasties consisting of Median, Chaldæan, and other kings. But, in truth, the attempt to assign a historical date or character either to Semiramis or to Ninus is as much labour lost as the effort to fix the date of the birth of the nine Muses, or the death of Medusa. 'Ninus and his queen Semiramis,' says Sir G. Cornewall Lewis, 'appear to be purely fabulous beings. The name of Ninus is derived from the city; he is the eponymous king and founder of Nineveh, and stands to it in the same relation as Tros to Troy, Medus to Media, Perseus to Persia, Ægyptus to Egypt, Lydus to Lydia, Mæon to Mæonia, Romulus to Rome. His conquests and those of Semiramis are as unreal as those of Sesostris. It is the characteristic of these fabulous conquerors, that, although they are reported to have overrun and subdued many countries, the history of those countries is silent on the subject. Sesostris is related to have conquered Assyria; and the king of Assyria was doubtless one of those whom he harnessed to his chariot. But the history of Assyria makes no mention of Sesostris. Semiramis is related to have conquered Egypt; but the history of Egypt makes no mention of Semiramis.' (*Astronomy of the Ancients*, 408.) It is scarcely worth while to notice the version of Dinon and other writers, that Semiramis was a courtesan, who, becoming the wife of Ninus, persuaded him to entrust her for five days with supreme power, of which she availed herself to put him to death and to establish her own dominion. It is more pertinent to remark that her mythical history presents features closely resembling the tales of PARIS, ŒDIPUS, PERSEUS, TELEPHUS, CYRUS, ROMULUS, Chandragupta, and other heroes and founders of dynasties. She is said to have

been a daughter of the fish-goddess Derceto of Ascalon, by whom she was exposed in her infancy. She was saved by doves, as Iamos was preserved by serpents, Paris by a she-bear, Romulus and Cyrus by a wolf or a dog. Like these, again, she is brought up by a shepherd, until her beauty attracts Onnes, one of the king's generals, who marries her. Ninus on seeing her is also captivated by her charms, and Onnes thereupon slays himself. In later traditions, her fame altogether eclipsed that of Ninus; she became the founder of Babylon, the builder of tombs more than a mile in height. To her were ascribed all those works of a prehistoric age, which may be classed with the cloacæ and other great works of ancient Rome; and, having performed wonders during her life, she vanishes from earth, like Romulus and HERACLES, and wings her way to heaven in the form of a dove.

In other legends, she comes forth in a character very different from that of an Amazonian queen. In these tales she is the counterpart of Aphroditê, the lover of Adonis (or Thammuz), and is said to have initiated the use of eunuchs, and introduced the marriage of mothers and sons. She is, in short, ASTARTE, the coarse Oriental ideal of the being whom the Greek described as Anadyomenê, the child of the bright sea-foam.

Semitic Languages. The name of that family of languages which is composed of the Aramaic, Hebraic, and Arabic dialects. The first of these branches is known to us chiefly through the Syriac and Chaldee. The Hebraic is represented chiefly by the ancient language of Palestine, the speech of the Jews being most closely allied to that of the Phœnicians and Carthaginians. The oldest documents of the third or Arabic branch are the Himyaritic inscriptions: this branch includes the Ethiopic or Gees, and the Arabic dialects. The grammatical framework of these languages is quite distinct from that of the Aryan languages; but the most salient point of contrast is perhaps furnished by the fact that the roots of the Semitic dialects, 'as far back as we know them, must consist of three consonants,' many words being 'derived from these roots by a simple change of vowels, leaving the consonantal skeleton as much as possible intact.' (Max Müller, *Lectures on Language*, first series, lecture viii.)

The following is given by Professor Max Müller as the genealogical table of the Semitic family of languages:—

Living Languages	Dead Languages	Classes	
Dialects of Arabic.			Semitic Family.
Amharic.	Ethiopic	Arabic or Southern.	
+	Himyaritic Inscriptions		
" the Jews.	Biblical Hebrew	Hebraic or Middle.	
+	Samaritan Pentateuch (third century A.D.)		
+	Carthaginian, Phœnician Inscriptions		
+	Chaldee (Masora, Talmud, Targum, Biblical Chaldee)	Aramaic or Northern.	
Neo-Syriac.	Syriac (Peshito, second century A.D.)		
+	Cuneiform Inscriptions of Babylon and Nineveh		

Semitone (Gr. ἡμιτόνιον). In Music, the half of a tone. Strictly speaking, this is not a proper definition of it, inasmuch as semitones are of different lengths, according to their nature. A diatonic semitone is when the name of the note changes, as, for example, from C to D♭, or from B to C; a chromatic semitone is when the note is merely altered by a sharp or a flat, as from C to C♯, or from D to D♭.

Semivowel. This term is applied to those consonants which, like vowels, can be pronounced independently, or without the aid of any other letter. To this class belong *b, d, c, g, k, p, s, t, v, x,* and *z*.

Semnopithecus (Gr. σεμνός, *venerable*, and πίθηκος, *an ape*). A genus of long-tailed Catarrhine monkeys, distinguished by the complex stomach, long canines, and the more obtuse facial angle from the other Guenons. The species of this genus are all found in India, where *Semnopithecus Entellus* (Hoonuman, or sacred monkey) has been deified. The slaughter of this animal, even by accident, is punished with severity under the Hindu laws.

Semo Sancus. In Mythology, the name of a Roman god, said to have been originally Sabine. The name Sancus, as connected with *Sancire*, points to his relation to law or an oath; and hence he was looked on as presiding over the laws of nations, hospitality, &c. The name Semo is thought by some to be a contraction for semihomo; but this, although possible, cannot be proved.

Semolina (Ital.; Fr. semoule). A granular preparation of wheat, used in cookery.

Sempervivum (Lat. *living always*). A genus of succulent shrubby or herbaceous plants belonging to the *Crassulaceæ*, and allied to *Sedum*, from which they are distinguished by having about twelve petals, and the glands at the base of the ovaries laciniated if present. *S. tectorum*, the Common Houseleek, is a well-known plant, with thick fleshy leaves arranged in the form of a double rose. It is commonly to be met with on the tops of outhouses and cottages, and is considered to possess cooling properties. *S. cæspitosum* has been known to remain alive in an herbarium for eighteen months, and, when subsequently planted, to grow.

Semuncia (Lat.). A small Roman coin, equivalent to half an ounce, being 1-24th of the Roman pound.

Senate (Lat. senatus; i.e. *assembly of elders*). The deliberative assembly of the Roman people. The members of this council were originally chosen from the patricians, and were probably single representatives of each of the houses of that order: a plebeian senator is first mentioned A. U. C. 355. Romulus is said to have fixed the number at 100, which (the legend says) was doubled on the admission of the Sabines, and increased to 300 by Tarquinius Priscus; the more ancient members and those admitted by this last king being distinguished by the titles of *patres majorum* and *patres minorum gentium*, or senators of the greater and of the lesser houses respectively. In the last ages of the republic, the members of the senate amounted to about 400, and were still further raised by the emperors to 1,000. The members of the senate are said to have been originally chosen by the kings, and afterwards the election fell into the hands of the consuls, military tribunes, and finally of the censors; but the fact of having held certain magistracies, as the quæstorship, and all superior posts, gave a right to this privilege. Under the regal government, the senate, it is said, deliberated on such affairs as the king proposed to them. On the establishment of the republic, the whole power of the state was thrown into its hands, the different magistrates exercising their authority merely as its delegates. The first constitutional check imposed on it was the power of intercession, or negativing their proceedings, granted to the tribunes of the commonalty. Still, while Rome was free, the authority of the senate, though subordinate to the assembly of the people, remained very great. It assumed the guardianship of public religion; the management of the revenue; the appointment of governors to the provinces, whose constitution it settled; the direction of diplomatic affairs; and many other functions of importance. Under the emperors, its power became, in general, little more than nominal; yet the assembly still existed till the occupation of Italy by the Goths in the thirteenth century after the foundation of Rome; and in the last ages of its existence, after the seat of empire had been transferred to Byzantium, it seems to have been the centre of what remained of the old national spirit. After that time, its existence as a council ceased, though the name of senator was still retained by some noble families of Rome as an empty but high-sounding title. The senatorial badges were the laticlave, or tunic with a purple band, black buskins reaching up to the middle of the leg, and a silver crescent on the foot.

The affairs of the Italian and provincial towns of the Roman empire, in imitation of the capital, were administered by senates. See as to these provincial senates, or curiæ, Savigny's *Hist. of the Roman Law*, vol. i.

SENATE. In many republican constitutions of modern times, the upper house of the national assembly has been so called. The senate of the United States [CONGRESS] is composed of two members for each state of the Union. The senators are chosen by the state for six years. The American senate, besides its legislative functions, is also a species of executive council, assisting the president; its consent being necessary for the ratification of treaties, appointment of ambassadors, judges of the supreme court, heads of departments in the administration, &c. It is also the high court of impeachment for public functionaries.

Senate was also the title of the upper legislative chamber in France under the first empire; and it has been renewed under the second. The senators are named for life, by the emperor; the number not to exceed 150. The constitutional powers of this body are very extensive, as it can interpret the constitution, decide on the legality of enactments, &c., by *Senatus-consulta* without the concurrence of the Corps Législatif.

Seneca Oil. The name given in some parts of North America to a Petroleum which exudes from the rocks, or floats on the surface of certain springs, after the Seneca Indians, who discovered the oil in Pennsylvania, and used it as a medicine both internally and externally. [NAPHTHA; PETROLEUM.]

Senecio (Lat.). A genus of *Compositæ*, remarkable as being probably the most extensive in point of species in the whole vegetable kingdom. They are spread over all parts of the globe, nearly 900 different kinds being known to botanists. The Groundsel, *S. vulgaris*, and the Ragwort or Ragweed, *S. Jacobæa*, afford a good idea of the appearance of the European species, the most noteworthy of which is perhaps the well-known *S. Cineraria*, better known in gardens as *Cineraria maritima*, extensively used for planting in flower-beds for the sake of contrast with scarlet and other colours, its beautiful foliage being clothed with short white down. The generic name *Cineraria* is, however, restricted to a few Cape plants, which differ from *Senecio* in the achenes of the ray-florets being winged. The beautiful early spring-flowering plants cultivated in greenhouses as *Cineraria* belong to *Senecio*, and have been obtained by horticulturists by intercrossing with each other a number of the Canary Island species, such as *S. populifolius*, *S. tussaliginis*, &c. The deep blue colour of some of the garden forms of these plants is singular in the genus, and not at all common in the family.

Senega Root. The root of the *Polygala Senega*, called Rattlesnake root. It is brought from North America, and has a peculiar pungent flavour, promoting the flow of saliva. In large doses, it nauseates and purges. It is occasionally used in stimulating gargles; and in America, as an antidote—probably a very inefficient one—to the effects of the bite of the rattlesnake. Its active resinous principle has been termed *Senegin*, and also *polygalic acid*.

Senegal Root. The diuretic and very bitter root of *Cocculus Bakis*.

Senegin. The bitter acrid principle of the *Polygala Senega*, or Rattlesnake root.

Seneschal. A French title of office and dignity (said to be derived from the old German word *senne*, house, and *schalk*, servant), answering to that of steward, or high steward, in England. They were originally the lieutenants of the dukes and other great feudatories of the kingdom; sometimes termed baillis or bailiffs. When the kings recovered the rights of suzerainty, and especially the judicial authority, in those provinces which had been previously governed by these great nobles, the bailiffs and seneschals continued as royal judges and superintendents, both military and financial; but their powers, like those of the dukes and counts whom they succeeded, were gradually encroached on by the crown.

Senna. The leaves of various species of *Cassia*, as *C. obovata, elongata, acutifolia*, &c. Large quantities are imported from Alexandria, whither they are brought from Upper Egypt. They are largely mixed with the leaves of *Solenostemma Argel*, which, however, are thick, and not ribbed like the genuine senna leaves. They have a nauseous, mucilaginous, bitter taste, and yield a pale brownish-green infusion. The true senna leaves are distinctly ribbed, thin, generally pointed, and when chewed have a peculiar nauseous flavour, and yield a dark brown infusion. It is a griping, nauseating, and somewhat drastic purge, but a valuable addition to, or vehicle for, other purgatives. Other kinds are imported from India. [CASSIA.]

SENNA. Various preparations of senna are used medicinally, and several different species of the plant are to be found in the markets supplying the drug. The Alexandrian and the Indian senna are chiefly used in this country. The former is collected in Nubia and Upper Egypt from the *Cassia acutifolia* and *obovata*. The latter going by the name of Tinnevelly senna grows in India, but in all probability is only naturalised there. It is the product of *Cassia elongata*. Senna contains a purgative principle called *cathartin*, and also an odorous volatile oil. It is an active purgative, possessing irritant qualities, and is apt to cause tenesmus and pain unless it be combined with aromatics.

Sensation (Lat. sensus, *feeling*). The act by which the mind receives, through parts of the nervous system, impressions of qualities or conditions of nervous bodies. Sensation is *common* or *special*. In its greatest perfection common sensation, or sensibility, constitutes touch. The special kinds are called the SENSES.

Senses (Lat. sensus). The faculties are so called by which we become acquainted with the properties and states of external things. They are five in number—sight, hearing, taste, touch, and smell: for the physiology of which the reader is referred to the articles; such as EYE, EAR, SMELL, &c. [NERVOUS SYSTEM.] Dr. Thomas Brown and Sir C. Bell have propounded the doctrine of a sixth sense, called the *muscular* sense (our whole muscular frame being supposed to be a *distinct* organ of sense)—a doctrine to which Dr. Whewell declared his adherence in his *Philosophy of the Inductive Sciences*, &c. For an able examination of the phenomena of the senses, see Bain's *The Senses and the Intellect*.

Sensibility. [SENSATION; SENSORY.]

Sensitive Plant. This name is generally applied to a small annual, called *Mimosa pudica*, inhabiting the tropics of America. It has a stem about a foot and a half high, covered with stiff hairs; the leaves are bipinnate in a somewhat digitate manner; and the flowers are collected in small pink balls. It derives its name from the irritability of its leaves, which collapse and fold up when touched, or even when irritated by casting on them the focus of a burning glass; or by exposing them to the vapour of hydrocyanic acid. The cause of this irritability has been investigated by Dutrochet (*Mémoires pour servir à l'Hist. Anat. et Phys. des Végétaux*, &c. vol. i. 534), who refers the phenomenon to the action of endosmose, and to the operation of a 'fibrous tissue capable of moving inward under the influence of oxygenation.' The nature of the phenomena may be thus explained: When the leaf of a sensitive plant is at rest, it consists of many leaflets spreading flat, and connected in pairs along the sides of certain common leaf-stalks. When one of these leaflets is irritated, the pair to which it belongs rise upward, and apply their faces to each other; this is rapidly followed by the same action in the succeeding leaflets, and in the course of a few seconds the whole of the leaflets are in a state of collapse; then the leaf itself suddenly bends downwards; and if the plant is in very good health, the shock thus communicated to one leaf will extend to those immediately above and below it. After a time the leaf resumes its original position. Upon the approach of night, that is to say, upon the withdrawal of light, the leaf falls of itself into the same state, without any special irritation.

This kind of irritability is by no means confined to the *Mimosa pudica*; on the contrary, some other species of the same genus, as the *M. dormiens, sensitiva, casta, somnians, palpitans*, &c., possess the same property, as is indicated by their names. And among the Leguminous order, it is also found beyond the genus *Mimosa*, as in the *Hedysarum gyrans*, whose three leaflets are in a continual state of dancing or balancing during the day. In fact, the folding their leaves at night, which is universal in all the compound-leaved species of this order, is the same thing feebly exercised. Nor is such irritability confined to this order; the ternate and pinnate leaved species of *Oxalis*, the *Dionea muscipula*, and numerous other plants, exhibit similar phenomena.

Sensorium (Lat. sentio, *I feel*). A term employed by physiologists for the central seat of sensation or of consciousness. It has been placed by Bontekoe and Lancisi in the *corpus*

callosum; by Willis in the *corpora striata*; by Descartes in the pineal gland; by Vieussens in the *centrum ovale*; by Boerhaave in the boundary line of the grey and white substance; by Mayer in the *medulla oblongata*; and by Camper in the pineal gland and *corpora quadrigemina*. The doctrines of Prochaska, on the contrary, affirm that wherever ganglionic structure exists sensation is also present. The *sensorium* is consequently coextensive with the nervous centres.

Sensory. This term appears to have been first applied by Hartley to those nerves which convey a stimulus to the neural axis or nervous centres with which they are connected, in contradistinction to the nerves which convey a stimulus from the neural axis to the muscles. 'The actions of sneezing, swallowing, coughing, hiccoughing, vomiting, and expelling the fæces and urine' are to be deduced 'from those vibrations which first ascend up the sensory nerves and then are detached down the motory nerves, which communicate with these by some common trunk, plexus, or ganglion.' (*On Man*, vol. i. p. 97.) This class of motions or vibrations, now called *reflex*, Hartley distinguishes from those produced by the transmission of the sensory vibrations to the brain, where they produce *sensation*, and excite *volition*; and the nerves producing the 'first and fourth classes of motory vibrations of Hartley's system' have been asserted to be anatomically distinct from those that produce sensational and volitional vibrations. The distinction has not been recognised, and anatomists apply the term *sensory* to those parts of the neural axis with which the sensory nerves are connected, as e.g. the posterior columns of the myelon, the optic lobes, the thalami and the corpora striata, which are termed *sensory ganglions*.

Sensualism. In Mental Philosophy, that theory which resolves all our mental acts and intellectual powers into various modifications of mere sensation. The best known, and the most elaborate attempt of this kind which has been made in modern times, is that of Condillac, who conceived that he was following out the principles of Locke into their legitimate consequences. For this belief it cannot be denied that there exists at least plausible ground. Locke does indeed draw a distinction between sensation and reflection, as separate sources of *ideas*; but his account of reflection is too vague to justify the attempt to reduce it to mere revived sensation. The theory opposed to sensualism is called *intellectualism*.

Sentence (Lat. sententia, *an opinion*). In English Law, the decree or judgment of the ecclesiastical or admiralty courts is so termed; also, in popular language, the judgment of a criminal court allotting the punishment of a convicted person.

Sentry or **Sentinel** (Fr. sentinelle). The name given to a soldier when posted on guard.

Senza (Ital. *without*). In Music, this term signifies without; as *senza stromenti*, without instruments; *senza violini*, without violins.

Sepals. In Botany, the divisions of that portion of a flower called the *calyx*.

Separate Estate. In Law, this term denotes property given or settled to the separate use and benefit of a woman, in respect of which equity (as administered in the Court of Chancery) treats her as an unmarried person, and she will consequently (notwithstanding her being married, or marrying afterwards) be entitled to it independently of her husband and of his debts, control, and engagements, and he will be bound, where necessary, to confirm and give effect to any disposition of it which she may make. It may be acquired either by prenuptial contract or settlement, or by gift or legacy from a husband or any other person.

Separatists or **Motazalites.** The name of one of the chief sects of the Mohammedans. They were the followers of Wasel Ebn Orta, who dissented from the main body of the Mohammedans about the fortieth year of the Hegira. Their leading tenets consisted in rejecting the eternal attributes of God; in denying the great doctrine of predestination, so zealously cherished by all the orthodox Mussulmans; and in asserting the free agency of man. This sect is said to have been the first inventors of scholastic divinity, and is subdivided into several inferior sects, which mutually brand one another as infidels. (Sale's *Koran*, Preliminary Discourse, vol. i. p. 212.) The great opponents of the Separatists were the Sefatians, who maintained the eternal attributes of God (hence they were called *Sefati*, or Attributists); but who afterwards adopted a belief in the outward resemblance of God to created beings. This sect was afterwards subdivided into various sects, the chief of which were the Asharians, Moshabbehites, Keramians, Jabarians, and Morgians.

SEPARATISTS. This name was given to a sect of Christians which originated in Dublin about the year 1803. Their principle, like that of most sects at their commencement, was to return more nearly to what they conceived to be the primitive form of Christianity. In the year 1833 an Act of Parliament was passed for their relief in the matter of oaths.

Sepawn or **Sepon.** Maize-meal boiled in water, used as food in the North American States.

Sepia (Gr. *the cuttle-fish*). In the Fine Arts, a species of pigment prepared from a black juice secreted by certain glands of the *sepia* or cuttle-fish, which the animal ejects both to darken the water when it is pursued, and as a direct means of annoyance. That this juice was used as ink by the ancients is well known.

> Tunc queritur, crassus calamo quod pendeat humor,
> Nigra quod infusa vanescat *sepia* lympha;
> Dilutas queritur geminet quod fistula guttas.
>
> PERS. *Sat. III.*

Pliny (*Nat. Hist.* l. ii. c. 29) says that it was the property of this fish, when it was enclosed by a net, to shed a black juice which so darkened the water that the fisherman could not see it. All the varieties of the sepia yield this juice; but the *Sepia officinalis*, which is so

common in the Mediterranean, is chiefly sought after for the colour which it affords. [MUREX.] It is insoluble in water, but is extremely diffusible through it, and is very slowly deposited. When prepared with caustic lye, it forms a beautiful brown colour with a fine grain, and has given name to a species of drawing now extensively cultivated for landscapes and other branches of the fine arts. The honour of the invention of the sepia drawing is due to Professor Seidelmann of Dresden, who discovered it at Rome in 1777.

Sepiadæ (Gr. σηπία). Cuttle-fish tribe. The name of the family of Decapodous Dibranchiate Cephalopods, of which the cuttle-fish (*Sepia officinalis*) is the type. They are characterised by the rudiment of a shell, in the form of a friable calcareous plate, embedded in the back part of the mantle, and of which the material called *pounce* is made.

Sepiola (dim. of sepia, *a cuttle-fish*). The name of a genus of Decapodous Dibranchiate Cephalopods, of which the species are of small size, and are characterised by short, rounded, advanced subdorsal fins, and a short internal horny style.

Sepiolite. A hydrated silicate of magnesia, with nearly the same composition as Talc. It is the Meerschaum of some authors, and the Magnesite of others.

Sepium. The bone or internal shell of the cuttle-fish.

Sepoy (a corruption of the Indian word sipahi, *soldier*). The designation of the native troops in her majesty's Indian army, formerly in the service of the East India Company. They were so called as early as 1708 (Mill's *British India*, book iv. ch. 1.), although at that period they do not seem to have been disciplined in the European fashion, nor, indeed, until long after other European powers had set the example. The first sepoys who were raised and regularly disciplined by the English seem to have been carefully chosen either from among the Mohammedan portion of the population, or from among the higher castes of Hindus, a considerable proportion of the latter being Rajpoots, the most warlike of Indian races; but the necessities of the service subsequently introduced a greater mixture in their ranks. The character of the sepoys as soldiers was always the subject of much discussion; they have justly been celebrated for excellent qualities; as, for instance, patience and fortitude under difficulties and privations. But, on the other hand, if we analyse the account of the wars in which they have been employed, we shall find that they seem to have possessed passive rather than active courage; for instance, that in line they remained steady under fire: in a broken or close country, however, where skirmishers and small detachments are necessarily most employed, they were found wanting. The mutinies of Vellore in 1806 and Barrackpore in 1825 should perhaps have shown that the sepoys were not to be trusted in the same manner as European troops; and the Indian mutiny of 1857-8 ultimately led to the disbandment of a great portion of the native army. The Bengal sepoys, it is well known, had been in a state of ill-discipline for a long time before the outbreak; and the absence on various employments, civil as well as military, of a large number of the officers, prevented their being properly controlled. The Madras sepoys, with few exceptions, remained firm to their trust; and their fidelity did much towards saving the Indian empire. Under a new régime it is to be hoped that many sepoys will never again be collected together without a sufficient force of European troops to hold them in check. It is probable that a certain number of native troops must always be employed in India to perform duties which the climate forbids to Europeans without great risk. (Kaye's *History of the Sepoy War.*)

Seps (Lat.; Gr. σήψ, from σήπω, *to putrefy*, in reference to the effects of its bite). The name of a genus of Saurian reptiles, which have a long round serpentiform body, and four very short legs, each terminated in the common seps (*Seps chalcides*) by only three toes.

Septaria. Flattened calcareous nodules found in clay, chiefly in the London clay and Kimeridge clay, but also in the Lias and elsewhere. They are segregations of the more calcareous portions of a deposit of marly clay, and are not unfrequently (perhaps always) collected round some organic body. Once formed, probably while the mass was wet, they have cracked in drying, and the cracks are filled up with crystalline carbonate of lime or calc spar. They are sometimes cut across and polished for ornamental purposes. Their chief use is to grind down, after burning, into hydraulic lime, for which their mixture of argillaceous matter with limestone makes them very valuable.

September (Lat. from septem, *seven*). This month, so called from its being the seventh month in the Roman year, established, as is supposed, by Romulus, is the ninth month in the so-called calendar of Numa. Several of the Roman emperors gave names to this month in honour of themselves; but, unlike the months of July and August, the name of September has outlived every other appellation.

Septembrists. The name given to the agents in the dreadful massacre which took place in Paris on September 2, 1792, during the French revolution. The numbers that perished in this massacre have been variously given; but the term has become proverbial throughout Europe for all that is bloodthirsty and malignant in human nature.

Septemviri Epulonum (Lat.). Certain priests in ancient Rome were so called, whose duty consisted in preparing the sacred feasts at games, processions, and on other solemn occasions. They were assistants to the *pontifices*, certain of whose privileges, such as the right of wearing the *toga prætexta*, they enjoyed. Their number was raised from three to seven, it is supposed, by Sylla.

Septennial Act. The stat. 1 Geo. I. sess. 2 c. 38, providing that the parliament which passed it, and all parliaments that should thereafter be called, might respectively have continuance for seven years, unless sooner dissolved.

Septentrional (Lat. septentrionalis). A word sometimes used to denote the northern portions of the globe. By the name septentriones, the Latins designated the seven stars which form the constellation of the Great Bear. For the real meaning and history of the term, see RISHIS.

Septic (Gr. σηπτικός, *making rotten*). A term applied by the old chemists and physiologists to certain substances supposed to promote putrefaction.

Septicidal (Lat. septum, *a hedge*, and cædo, *to cut*). In Botany, that mode of dehiscence in which the fruit is resolved into its component carpels, which split asunder through the dissepiments.

Septifragal (Lat. septum, and frango, *to break*). In Botany, that mode of dehiscence in fruits in which the backs of the carpels separate from the dissepiments, whether formed by their sides, or by expansions of the placenta.

Septuagesima (Lat. sc. dies, *the seventieth day*). In the Ecclesiastical Calendar, the third Sunday before Lent; the first Sunday in Lent being termed Quadragesima (fortieth), the three preceding ones Septuagesima, Sexagesima, and Quinquagesima.

Septuagint (Lat. septuaginta, *seventy*). The Greek translation of the Old Testament made at Alexandria for the advantage of the Jews of Egypt, who had lost the use of the Hebrew language. According to the old tradition, this version was the work of seventy-two interpreters, who were shut up in separate cells by the command of Ptolemy Philadelphus, and there completed the whole translation alone, in which, upon examination, they were all found to agree to a letter—a prodigy which established the inspiration of the work. It is supposed, however, by modern critics, that this version of the several books is the work not only of different hands, but of separate times. The authority of the Septuagint, as compared with the Hebrew text, from which it differs in many points, has been the subject of much controversy. It is from this version that the authenticity of the Apocrypha, which are not found in the Hebrew, is asserted by Roman Catholic writers. The quotations of the Old Testament which are found in the New are for the most part given in the words of the Septuagint.

Septum (Lat. septus, part. of sepio, *I fence in*). In Anatomy, the plate or wall which separates from each other two adjoining cavities; as the septum transversum, or diaphragm, between the chest and the abdomen; the septum narium, between the two nasal passages; the septum ventriculorum in the brain; and in the heart, &c. The partitions of chambered shells are also called *septa*.

SEPTUM. In Botany, any partition separating a body into two or more cells in a direction parallel with the longer axis. Partitions parallel with the shorter axis are called *phragmata*.

Sepulchre. [TOMB.]

Sepulchre, Church of the Holy. By this name is commonly known the church at Jerusalem, of which the Greek and Latin communions each have partial possession, and which, according to the present local tradition, stands on the site of the church erected by Constantine, near the tomb in which the body of Christ was laid in the interval between the Crucifixion and the Resurrection. This popular tradition involves the maintenance of three propositions: (1) that the present building stands on the site of a previous church which had been destroyed; (2) that the church so destroyed was the building erected by Constantine; (3) that the tomb over or near which it was built was the actual sepulchre in which the body of Jesus was laid.

On this proposition has arisen a complicated controversy, of sufficient importance to justify our giving a summary of the arguments employed on both sides.

Denying the three propositions involved in the current tradition, Mr. Fergusson maintains that the church built by Constantine was not on the site of the present sepulchre, but is the building commonly known as the mosque of Omar. The grounds on which he bases this conclusion are chiefly architectural and topographical, while he also holds that the documentary evidence is substantially on his side.

A thorough familiarity with Mohammedan buildings in India and other eastern countries had convinced Mr. Fergusson that the circular shape of the mosque of Omar was proof conclusive that it was built not as a mosque, but as a tomb, the essential definition of a mosque being that it is a wall at right angles to the direction of Mecca, whereas the round form is common to Mohammedan and other tombs. But the mosque of Omar has four entrances facing the cardinal points of the compass, the principal entrance facing south, so that a worshipper would enter by turning his back on the kaaba. In the absence, however, of any tradition that Omar or any Mohammedan saint had been buried under the dome, the conclusion was forced upon him that this was a Christian sepulchral building, and that it could only be the edifice raised by Constantine over what he believed to be the tomb of Christ. Laying down the general position, that in every instance of conflicting evidence an appeal to style is at once allowed to override the most minute and circumstantial written testimony, Mr. Fergusson institutes a comparison between the mosque of Omar and buildings ranging from the third to the seventh or eighth centuries, and concludes that the Khubbet-es-Sakrah (or Dome of the Rock, or mosque of Omar) is later in date than the palace of Diocletian at Spalatro, but earlier than Justinian's church of St. Sophia at Con-

stantinople, and that the building known as the Golden Gateway is a work of the same age. It is true, the Moslem tradition since the Crusades assumes that the Dome of the Rock covers the site of the altar or holy of holies of Solomon's temple; but as neither the Bible, nor the Talmud, nor Josephus mentions a rock as connected with either the altar or the holy of holies, the tradition is worthless, while it may also be shown that the rock Sakrah was altogether outside the temple area, and could not have sustained the altar under any circumstances. If, on the other hand, it be said that the presence of classical or late Roman details in the Dome of the Rock may be accounted for by the employment of columns and capitals taken from ruined buildings, Mr. Fergusson answers that, if it were a portico of four or six pillars, with twenty or thirty feet of entablature, anything might be assumed, but confining the argument to the aisle screen alone, eight piers, sixteen pillars, and 400 feet of entablature mitreing at all sorts of angles, and fitting everywhere without any appearance of contrivance or adjustment, present a phenomenon not to be explained away, while the building is just such an one as we should find emanating from Constantine's order that 'the church may surpass all others in beauty.'

These conclusions Mr. Fergusson holds to be generally borne out by historical documents. Thus Eusebius, he affirms, speaks of a round church as built over the sepulchre, and distinct from the great basilica which adjoined it. These buildings, were, it is said, destroyed by fire during the sack of the city by the Persians in 614; but this fire, he thinks, has been as useful to those who adhere to the current tradition as the conflagration at Wolf's Crag was to Caleb Balderstone, the damage done in both cases being much the same. The great proof of this is the fact that a simple monk, named Modestus, restored the whole to their pristine magnificence without means or money. And again, the history of the Mohammedan conquest proves that the Sakrah is not the rock of Omar, the position of which is clearly marked out by that of the gate of Mohammed as being within the substructure of the temple; and, finally, Arculfus, a pilgrim of the seventh century, mentions (1) the Anastasis or round church, containing the sepulchre; (2) the square church of St. Mary; (3) the large church of Golgotha; (4) the Basilica or Martyrium, built by Constantine with great magnificence.

If, then, this is a true account of the facts, a transference of the site took place at some time or other subsequent to the conquest by the Saracens. Of this transference there is no record, but the fact is as easily explained as the transference of the Santa Casa to Loretto, and may have been caused by the envy of the Moslems, who, after the capitulation of Omar had fallen into desuetude, cast longing eyes on the Dome of the Rock, either because they were offended that the Christians should possess a more splendid building than themselves close to their own mosque El Aksah, or because they coveted the custody of the tomb of Christ, whom they looked upon as the greatest of prophets next after Mohammed. When, in the eleventh century, the Christians crept timidly back to Jerusalem, they built themselves a church in their own quarter of the town, and to this church were gradually transferred the traditions of the sites from which they had been dislodged.

If any objection be made to this theory on the score of the character in which the inscriptions round the dome of the Sakrah are written, Mr. Fergusson meets it by remarking that, although a writing in Coptic characters runs round the dome, one short paragraph in it is said to contain the name and date of the builder; and as it is allowed that either the name Al Mamoun, or the date, 72 Heg., A.D. 691, is a forgery, no argument can be based upon it, while his own opinion remains that, notwithstanding the evidence of the Coptic character of the writing, the whole is of the time of Saladin. (*Essay on the Ancient Topography of Jerusalem*, 1847; *Notes on the Site of the Holy Sepulchre at Jerusalem*, 1861; *The Holy Sepulchre at Jerusalem*, being Two Lectures delivered at the Royal Institution, 1865.)

In opposition to these arguments and conclusions of Mr Fergusson, it is maintained that the tradition which claims for the present Church of the Sepulchre the site of the building raised by Constantine has no necessary connection with the genuineness of the tomb said to have been discovered by Constantine, and that this part of the question may accordingly be dismissed. And, further, it is argued that the architectural evidence cannot in all cases be received with the unhesitating reliance which Mr. Fergusson places in it; that there are or may be special reasons for distrusting it when we are dealing with the work of a people who, having no style of their own, are in the habit of employing the architects and builders of conquered nations; that in the case of Waltham Abbey the documentary evidence is neither undisputed nor conclusive, as Mr. Fergusson takes it to be; that the architectural evidence is not in this case received, in the truth of the documentary evidence, as proving that the whole of the present building was erected after the Conquest; and that we have no right, as Mr. Freeman argues (*Gentleman's Magazine*, February 1861), to admit without evidence such an hypothesis as that of Mr. Fergusson, who suggests that the ecclesia in which Harold was first buried was a round church which has utterly perished.

In support of his theory, Mr. Fergusson has adduced the basilica of San Clemente at Rome, originally erected in the fourth century, and of which he feels convinced that we have now the original apse with its ornaments, except the cross in the centre, which is an interpolation of the thirteenth century, the nave belonging perhaps to the eighth, and the choir to the ninth century. To this it is replied that the recent

discovery of the lower church of San Clemente, the frescoes of which, belonging in some instances to the tenth and eleventh centuries, show that this church was in use long after it was supposed to have been superseded by the existing church, compels us to assign to the latter a date which sweeps away Mr. Fergusson's theory about the apse of the existing church with its decorations, inasmuch as the lower level of the previous building precludes the idea that that apse is a remnant of the original building.

On the subject generally, it is maintained by Professor Willis, the Rev. G. Williams, Count de Vogüé and others, that the reputed Sepulchre contains indubitably a rock-hewn tomb, whether the Sakrah be likewise a tomb or not; that the building in which it stands was demolished first by the Persians, and more systematically by the order of Hakem, when every effort was made to destroy the sepulchre by iron hammers and fire, while the Khubbet-es-Sakrah has escaped uninjured, and the rock exhibits no sign of having undergone such treatment. It is further argued that the language of Eusebius does not warrant the existence of any round church over the holy sepulchre, as he merely says that Constantine adorned the cave, as such, with choice columns and abundant decorations, and that the cave thus adorned opened into a large hypæthral court, surrounded by cloisters on all sides excepting the one facing the entrance to the cave, the basilica being on this side, precisely facing the cave and looking east; that the words of Eusebius leave no room for thinking that the sepulchre was contained in a separate building, and that the title, τὸ μαρτύριον τῆς ἀναστάσεως, applied to the basilica set aside the distinction drawn between the dome of Omar as the Anastasis and the Basilica as the Martyrium. Mr. Fergusson, it is urged, finds two buildings, the mosque of Omar, and the Golden Gateway, of which he takes one to be the actual sepulchral church, and the other to be the entrance to the atrium of the basilica; and his restored plan, formed from these data, exhibits a basilica, whose western end, so far from being precisely opposite to the sepulchre, does not even face any side of the Khubbet-es-Sakrah whatever. Again, the mosque of Omar is a rotunda; but the present church of the sepulchre furnishes evidence that the former building on the same site was not a rotunda, more than half the aisle of the present rotunda being bounded by a concentric wall, in which are placed three small apses, one at the west end, the others on the north and south. If the design of the original church had been round, the north and south apses must have had their axes on the diametral line of the rotunda; but Professor Willis remarks that the line falls to the eastward of both these apses, and thus corroborates the description of Eusebius, who likewise speaks of the propylæa as opening upon the middle of the great market place. The east end of the present church still opens on a street of deserted bazaars; and as the Golden Gateway looks down immediately on the valley of Jehoshaphat, the theory of Mr. Fergusson is rendered, in the judgment of Professor Willis, 'ludicrously impossible.'

Further, it is urged that the form of the Khubbet-es-Sakrah proves only that the building was designed to preserve the rock which forms its area, and that this rock is reverenced by the Mohammedans for reasons not connected with the sepulchre of Christ; that the round church of Modestus, completed half a century before Abdal Malek commenced the mosque, if it be his work, may have suggested the form, while the Greek character of the details is evidence that it was not wholly or in great part built by Saracenic workmen; and that the dome is confessedly of pure Mohammedan architecture. It is also maintained that, while the Dome of the Rock exhibits no signs of the violence from which the church of the sepulchre is said to have suffered repeatedly, the words of Eusebius seem to state positively that the church of Constantine was built on a hill opposite to that on which the Jewish temple had stood, the *new Jerusalem* being a name employed by him and by Socrates to designate the Martyrium of the Anastasis itself; and that the language of Arculfus, who speaks of a round cabin cut out of a single piece of rock in the middle of the round church, containing a space large enough for nine men to stand and pray, seems to be not less unsuitable as the description of a rock projecting to a height varying from six to ten feet, and having a diameter of nearly fifty feet.

It is further maintained that the whole inscription running round the Dome of the Rock, with the exception of the one name of Al-Mamoun, is written in characters which were in use at the time of Abdal Malek, the real founder, but which had become obsolete long before the age of Saladin, to which the inscription is assigned by Mr. Fergusson; that the Mohammedans did not appropriate the building because it was built in honour of Christ; that the inscription which denies His divinity is no evidence of any supposition on their part that this building contained His sepulchre, and that, in fact, the Moslems, adopting the Gnostic notion that a phantasm was substituted at the Crucifixion, have no belief in the death of Christ, and hold the tomb of Christ in abhorrence as being the tomb of His betrayer.

Finally, it is maintained that all the architectural difficulties raised by Mr. Fergusson have been practically solved by recent discoveries of Count de Vogüé in Central Syria, which prove that the trabeate and arcuate construction characteristic of the Dome of the Rock, was the prevailing feature of the large churches in the province of Antioch, so late as the seventh century, and that these churches furnish the very type with which the builders of the Khubbet-es-Sakrah would be most familiar, and which they would naturally copy in the buildings which they were employed to erect whether

for their Christian or Moslem employers. (De Vogüé, *Les Églises de la Terre Sainte*; Williams, *Holy City*, including an *Architectural History of the Church of the Holy Sepulchre*, by Professor Willis; Robinson, *Biblical Researches in Palestine*; *Edinburgh Review*, October 1860, art. 'Churches of the Holy Land;' *Quarterly Review*, October 1864, p. 404, &c.

Sepulchre, Hospitallers of the Holy. An order of knighthood, originally instituted in Palestine, afterwards established in France by Louis VII., and united by Pope Innocent VIII. to that of Malta; but the order still continued to exist in France, and was taken under protection by Louis XVIII. in 1814.

Sepulchre, Regular Canons of the Holy. A religious order, instituted at Jerusalem. These canons were introduced also into France, Poland, Flanders, and England. The order was suppressed by Innocent VIII., and its revenues passed ultimately into the hands of the knights of St. John of Jerusalem.

Sepulture, Rites of. This term denotes literally the ceremonies performed in depositing the bodies of the dead *in the earth*; but the expression is applied in a more extended signification to all funeral ceremonies. The three chief modes of treating the dead that have prevailed from the earliest ages down to the present times are burning, interment, and embalming. Among the Greeks and Romans, both incremation and interment prevailed, though the former was by far the most frequent. The practice, peculiar to the Egyptians, of embalming their dead, has been noticed under MUMMY; and the Indian custom of immolating women on the funeral pile of their husbands will be found under SUTTEE. The practice of interment has been adopted by all the nations that have embraced Christianity. [CEMETERY.]

Sequence (Lat. sequentia, *a following*). In Music, a similar succession of chords ascending or descending diatonically.

Sequestration (Lat. sequestratio, from sequester, *a go-between* or *mediator*). In English Law, a species of execution for debt in the case of a beneficed clergyman, issued by the bishop of the diocese on the receipt of a writ to that effect. The profits of the benefice are paid over to the creditor until his claim is satisfied. *Sequestration* is also, in Chancery, a process for enforcing the decrees or orders of the court by seizure of the property of a person guilty of disobeying them.

SEQUESTRATION. In Scottish Law—1. A species of diligence (i.e. a process), used where two or more creditors are in competition for the property of a land estate, the owner of which is in insolvent circumstances; or where the right to a land estate is the subject of litigation. In these cases the court may, on application, sequestrate the rents, and employ a factor to collect them. 2. Sequestration is also the process whereby the whole estate, both heritable and movable, of a bankrupt, is distributed equitably amongst his creditors. It is granted on application to the court of session by the bankrupt, with the concurrence of one or more creditors, or on their application, and on citation of the bankrupt. It is analogous to a bankruptcy in English law.

Sequin (Ital. zecchino; from zecca, *a mint*). The gold pieces of Venice were originally so called; afterwards the name was extended to other gold coins in use in the Mediterranean, as those of the pope, the sultan, Florence, and Genoa. [MONEY.]

Sequoia. A genus of *Coniferæ* from North-Western America, consisting of two species only, and closely allied to *Sciadopitys*, being distinguished from it principally by its peltate scales without bracts, and five to seven seeds. *S. sempervirens*, the Redwood of the timber trade, extends from Upper California to Nutka Sound. It attains gigantic dimensions, being frequently more than 300 feet high, imparting to the woods of its native country a peculiar character—'something,' Douglas tells us, 'which plainly shows that we are *not* in Europe.' The Redwood has long been an inmate of our gardens, and principally differs from the *Wellingtonia* in having linear rather obtuse leaves whitish beneath.

S. Wellingtonia (the *Wellingtonia* of our gardens, and the Big or Mammoth-tree of the Americans) was at first thought to be confined to a single spot, the so-called Mammoth Grove of Calaveras in Upper California; but it has since been found in the Mariposa and Frezno Groves, and in various other parts of the Sierra Nevada, though nowhere attaining such a height as in the spot where it was first dis-

Sequoia Wellingtonia.

covered, in June 1850, by an American hunting-party. The tallest tree of the Mammoth Grove, stripped of its bark for the purpose of being exhibited, was 327 feet high, and at the base was 90 feet in circumference. The greatest dimensions seem to have been attained by a tree which was found broken at a height of 300 feet, and which measured at that place 18 feet in diameter. Considering that it was 112 feet in circumference at the base, and tapered regularly to the point where broken,

it is calculated to have been when in the fulness of its growth 450 feet high. It was at first thought that these trees might be 3,000 years old, but that estimate has since been reduced, by actual counting of the concentric rings, to about 1,100 years. This fine hardy evergreen tree was introduced into Europe in 1853, and stands our climate remarkably well. The wood when first cut is white, but ultimately turns mahogany colour.

Seraglio. An Italian corruption of the oriental word *serai.* The palace of the Turkish sultan in Constantinople is thus designated by European writers. The principal gate of the seraglio is the Babi Humayun, or Sublime Gate, whence the ordinary title of the Turkish government is derived.

Seraphim, or **Jesus, Order of the.** An ancient Swedish order of knighthood, instituted in 1334; but dormant from the period of the Reformation until 1748. The number of knights, besides the king and members of the royal family, is limited to twenty-four.

Seraphine. A name formerly used for the instrument now called the HARMONIUM.

Seraphs or **Seraphim** (Heb.). In the Angelic Hierarchy of the Jews, the angels of the highest rank. They are represented as surrounding the throne of God, whose messengers they are, and as being more immediately inspired with the Divine love, which they communicate to the inferior inhabitants of heaven. They are almost invariably spoken of in connection with the *cherubim,* whom they resemble both in rank and attributes.

Serapis. An Egyptian deity. The image and worship of this god were brought from Sinope in Pontus to Alexandria, in the last year of Ptolemy Soter, in consequence, it is said, of a vision of Ptolemy I.

The magnificent Serapeum, or temple of this god, at Alexandria, one of the most splendid of pagan temples, was destroyed by order of the emperor Theodosius during the struggle between the Pagan and Christian population of the city, A. D. 390. (Milman's *History of Christianity,* book iii. chap. viii.)

Serasquier. The name given by the Turks to the commanders-in-chief of their armies. It is compounded of two Persian words, signifying *head of an army.*

Serenade (Span. serenata, from Lat. serenus, *clear*). This word signified originally music performed in the open air on a *serene* evening; but is now universally applied to a musical performance by gentlemen under the windows of ladies whom they admire. This practice, which was formerly very general in Spain and Italy, has latterly fallen greatly into disuse in these countries; but it is still very common in the German university towns, where the students are in the habit of assembling in the evening under the windows of a favourite professor, and offering him a musical tribute.

Serene, Serene Highness, Serenity (Ger. durchlaucht). Titles of courtesy in European etiquette, of considerable antiquity. Before the dissolution of the German empire, Serene and Most Serene Highness were the appropriate addresses of princely houses holding immediately of the empire. Since that period the rules of princely etiquette have become more uncertain; but it appears to be the general principle that these titles belong of right to members of the families of sovereign houses in the confederacy, and also to members of ci-devant sovereign houses *now mediatised*: and that sovereign princes can moreover concede these appellations to princes not sovereign within their own dominions, yet not so as to give them a title to it out of them. But the distinctions as to the mode in which these titles are to be employed in addressing superiors, equals, and inferiors, are extremely complicated.

Serf (Lat. servus, *a slave*). When the mass of a community, being engaged in agricultural pursuits, hold land at fixed labour rents, and are tied to the soil, or only released from it by an agreement, capitation tax, or formal manumission, such persons are called *serfs*; and by a natural analogy, when legal enactments tend to bind labourers to a particular locality or calling, persons are accustomed to speak of such a population as serf. A serf differs from a slave by the fact that his amount of labour is fixed, and is ordinarily given in compensation for land—the remainder of the produce, after his service is given, or a money commutation for it paid, being his own property, whereas the slave has no property and can be taken away from the soil and disposed of at the pleasure of his owner. Serfdom, under the name of villenage, was slowly extinguished in England before the Reformation; it lingered in Scotland till the close of the last century, when the last relics of it were finally abolished. In the Russian social system, one of comparatively late origin, the mass of the community were serfs; but within the last few years serfage has been put an end to in that country. [OBROK; RYOT; SLAVERY; VILLEIN.]

Serge (Fr.; Span. xerga). A cloth of quilted woollen, extensively manufactured in Devonshire and other English counties.

Series (Lat. from sero, *I join together*). An Algebraical expression whose successive terms are formed according to some general law. According as the number of its terms is limited or unlimited the series is said to be finite or infinite. With respect to series, the principal questions which arise are how to develope a given finite expression in a series, how to find the expression or *generating function,* from which a series has originated, how to express any *general term* as a function of the number *n* of that term, and how to find the sum of any given number of terms or the limit to which, in the case of a convergent series, that sum approaches the greater the number of terms added. [CONVERGENT AND DIVERGENT SERIES.] The most effective way of developing an expression in a series is furnished

by the differential calculus (Taylor's *Theorem*), whilst the calculus of finite differences enables us frequently to ascend from the general term to the sum of any number of terms.

Series derive their names from the laws which govern the formation of their successive terms. Thus, an *arithmetical* series is one whose consecutive terms have a common difference; a harmonic series one of which every three successive terms are in a harmonic proportion. A *geometric series* is one every term of which has a constant ratio to the preceding one; it belongs to the family of *recurring series* in which each term is a constant function of one or more preceding terms.

The theory of series constitutes an extensive and very important branch of mathematics. Amongst the numerous works on the subject may be mentioned Euler's *Introductio in Analysin Infinitorum* and *Calculus Differentialis*, Cauchy's *Cour d'Analyse* and *Exercices de Mathématiques*, Catalan's *Traité Élémentaire des Séries*, and *Penny Cyclo.* art. 'Series.'

Serjeant (Fr. sergent, from Lat. serviens). A non-commissioned officer in the army, of higher rank than a corporal. There are serjeants and staff-serjeants; among the latter are serjeant-majors, quartermaster-serjeants, &c. The regimental serjeant-major acts as assistant to the adjutant. There are colour-serjeants in infantry regiments, troop serjeant-majors in cavalry, and battery serjeant-majors in artillery. There are a certain number of serjeants to each company, troop, or battery, and they have general duties of supervision.

Serjeant. Serjeant-at-law is the highest degree in the common law, and all must proceed through this degree before attaining the dignity of judge. In practice, however, the two dignities are usually conferred simultaneously. The Court of Common Pleas was formerly open to serjeants only for the purpose of pleading, while the court was sitting in *banc*, they having been anciently the only advocates recognised in the common law. This exclusive privilege was attempted to be taken away in 1834, and for five years the court was thrown open. But, after solemn argument, it was decided by the privy council that this enlargement was unwarranted, and the former practice again prevailed until the monopoly of the serjeants was finally abolished and the court thrown open to the bar at large by stat. 9 & 10 Vict. c. 52. Serjeants-at-law are now made by the royal writ, commanding them to take their degree. No precise time seems necessary to permit a barrister to become a serjeant. This office is seldom now assumed by practising barristers except by those who practise mostly in the criminal courts, and who wish to be able to hold leading briefs for the defence of prisoners without the necessity, in every case, of obtaining a license to appear against the crown, which as queen's counsel they would be obliged to do. [Queen's Counsel.] (Serjeant Manning's *Serviens ad Legem.*)

Serjeant, The Common. An officer of the corporation of the city of London, discharging some judicial functions.

Serjeant, King's or **Queen's.** One or more of the serjeants-at-law, whose presumed duty is to plead for the crown in causes of a public nature, as indictments for treason, &c., but the title is now merely honorary.

Serjeants-at-Arms. Officers whose duty is to attend the person of the sovereign, or of the lord high steward when sitting in judgment on a traitor, &c. They formerly formed a sort of body-guard, whose number was restricted by an ancient law (13 Rich. II.) to thirty, but their functions in this capacity have long become obsolete. Two serjeants-at-arms are allowed by the sovereign to attend at the houses of parliament during their sittings, and each has a deputy. In the House of Lords, the practical maintenance of decorum below the bar, near the throne, and in the gallery, devolves upon the gentleman and yeoman usher, with their assistants, so that, 'the serjeant-at-arms attending the House of Lords' has less conspicuous duties to perform than those which devolve upon 'the serjeant attending the House of Commons:' both, however, execute the commands of the house to which they belong, as regards the apprehension or custody of all persons committed by order of parliament. In the House of Commons, the serjeant-at-arms is an officer of considerable importance, enjoying large emoluments, assisted by a deputy and several subordinate officers. During the sittings of the house he occupies a chair below the bar, and directs a large proportion of the arrangements connected with the maintenance of order in the approaches to the house and the offices adjacent. He is at once the executive and the ceremonial officer of the lower house; but his discretionary powers are not extensive, for almost all his more important duties are performed under the immediate direction of the house itself, communicated through the speaker. The office is usually held by a gentleman of the military profession, seldom under the rank of a field officer.

Serjeanty, Grand and Petty. In the English Law of feudal tenures. Tenure by grand serjeanty was where the tenant held land of the king by service, to be performed in his own person, in his wars, &c.; such as to bear a banner or spear, or to assist at his coronation. Tenure by petit serjeanty was where the owner was bound to contribute some small thing towards military service, &c.; such as a sword, dagger, bow, or spear. Tenure by grand serjeanty was preserved by stat. 12 Ch. II., which abolished the other feudal tenures, and still subsists in some cases. Tenure by petit serjeanty is not referred to in stat. 12 Ch. II.; and the Blenheim and Strathfieldsaye estates, bestowed by the nation as the reward of public services, are held of the crown by this tenure, the dukes of Marlborough and Wellington being each bound to render a small flag annually.

Sermon (Lat. sermo, *a discourse*). In Ecclesiastical usage, the sermon or homily as a portion of the communion service is said to be of remote antiquity. This ancient custom fell into partial disuse during a great part of the middle ages. The Homilies of Ælfric, archbishop of Canterbury in the tenth century, were long used in the English church; but these became antiquated; and in the year 1281 (Palmer, *Orig. Liturg.* vol. ii. ch. iv.) preaching seems to have been generally omitted. In that year, Archbishop Peckham ordered, in his Constitutions, that four sermons should be delivered during the year. But for some time prior to the Reformation preaching was again coming more into use; and the publication of homilies by authority went far towards restoring the ancient practice. [HOMILY.]

Seron (Span.). A buffalo's hide, used for packing drugs and other articles.

Serosity (Lat. serum). The liquid which exudes from the serum of the blood when it is coagulated by heat. It is water holding some of the salts of the blood and a trace of albumen in solution.

Serpens or **Serpens Ophiuchi.** In Astronomy, one of the ancient constellations in the northern hemisphere.

Serpent (Lat. serpens, part. of serpo; Gr. ἕρπω, *I creep*; SARPEDON). A musical brass wind instrument, serving as bass to the horns or cornets. It is most generally covered with leather, and has three parts: a mouthpiece, neck, and tail. The compass is two octaves, produced with six holes stopped with the fingers. The serpent is chiefly used for accompanying Gregorian music in Roman Catholic churches. It is rarely employed in the modern orchestra.

SERPENT. In Mythology, the serpent played an important part. By some nations it was regarded as the emblem of cunning, deceit, and wickedness (compare the narration of the fall of man in Genesis with the Persian myth of Ahriman and Ormuzd); by others, such as the Egyptians and Phœnicians, it was looked upon as a good genius; while by the Greeks and Romans, it appeared under a variety of symbolic representations. With the latter, the serpent was the well-known emblem of the healing art; and in the present time a serpent with its tail in its mouth is regarded as an emblem of eternity. The serpent appears also in the Scandinavian mythology. [DRAGON; VRITRA.] In the early ages of the Christian church, a sect of the Gnostics also worshipped the serpent, whence they were called OPHITES. Dr. Donaldson identifies the serpent mentioned in Genesis iii. with the PHALLUS. (Jashar, *in partem primam Commentarius*, p. 47.)

SERPENT. In Zoology, a general name for the species of the order *Ophidia*.

Serpents are divided into spurious, or *Pseudophidians*, and true, or *Ophidians* proper. The *Pseudophidians*, although presenting the well-marked external characters of the order, retain an imperfect pelvis, a small sternum, scapulæ, and coracoids or clavicles, hidden beneath the skin; whereby, as well as in the structure of the skull, they approach the Saurian order. The common blind-worm (*Anguis fragilis*) is a native representative of the *Pseudophidian* family.

The true serpents have neither sternum nor vestige of the scapular arch: they have no third eyelid, nor tympanum; but the auditory ossicle exists beneath the skin, and its handle passes behind the tympanic bone. Several species retain a vestige of hind-limbs, which in some even shows itself externally in the form of a small hook. The chief subdivisions of the true *Ophidians* are: the *Amphisbæna*; the *Typhlopes*; the *Roles* (*Tortrix*); the *Boas*; the *Pythons*; the *Colubers*; the *Acrochords*—all which tribes are non-venomous. The *Pseudoboas*, *Rattlesnakes*, *Trigonocephali*, and *Vipers* are the venomous tribes; and are distinguished by having the superior maxillary bones short and movable, supporting fewer teeth than in the non-venomous serpents, and having the first of the short series larger than the rest, sometimes the only conspicuous fang, and traversed by the duct of a poison-gland, around which duct the tooth is, as it were, longitudinally folded, so as to appear perforated by a canal. The last tribe of true serpents includes the *Hydrophides*, or sea-snakes, which have likewise a poison-gland and duct, the latter being enclosed by the last instead of the first of the maxillary series of teeth. The tail of the sea-snakes is flattened vertically, and forms their chief organ of swimming. No species of this family has yet been discovered which exceeds ten feet in length.

The remains of an extinct genus of serpents (*Palæophis*), indicating species of from ten to twenty feet in length, have been discovered in the Eocene tertiary formations in Suffolk, Kent, and Sussex. (Prof. Owen's paper in the *Geol. Trans.*, second series, vol. vi. p. 209.)

Serpentarius. One of the ancient northern constellations, represented on the globes by the figure of a man grasping a serpent (*serpens*) in his hand. [CONSTELLATION.]

Serpentary Root. The root of *Aristolochia Serpentaria*.

Serpentine. A hydrated silicate of magnesia found disseminated in rocks, or forming large rock-masses, as in the Lizard district in Cornwall. The stone from this locality as well as that from Portsoy in Banffshire is much used for ornamental purposes instead of marble, being soft and easily worked, and susceptible of a fine polish. The name has reference to its spotted and veined appearance, like that of a serpent's skin.

SERPENTINE. A cannon of the fifteenth and sixteenth centuries, somewhat larger than the culverin. The name first appears in France about 1450, and in England a few years later. [CULVERIN.]

Serpigo. [RINGWORM.]

Serpuleans (Lat. serpo, *I creep*). The name of a family of Cephalobranchiate Anneli-

dans, inhabiting cylindrical and tortuous calcareous tubes; generally parasitic on shells.

Serradilla (Port.). A fodder plant not much cultivated in this country. It is a small Leguminous annual, the *Ornithopus sativus* of botanists.

Serrate (Lat. serratus, from serra, *a saw*). In Zoology, when a part is cut into teeth like a saw, or is armed with teeth whose sides are unequal.

Serricorns (Lat. serra, *a saw*; cornu, *a horn*). The name of a family of Coleopterous insects, comprehending those which have serrated or saw-shaped antennæ.

Sertularia (Lat. sertum, *a wreath*). The name of a genus of compound tubular Polypes; restricted, in modern zoology, to those species in which the cells are arranged on two sides of the stem either opposite or alternate.

Serum (Lat. *whey*). In Anatomy, the constituent of the plasma, or liquor sanguinis, which remains after the separation and coagulation of the fibrin. Serum contains a large quantity of albumen, and coagulates at a temperature of from 160° to 170°.

Serval. A species of spotted cat (*F. serval*, Cuvier) found at the Cape of Good Hope. The species there represents the lynx of Europe and the ocelots of South America.

Servetists. In Ecclesiastical History, a name which has sometimes been given to Unitarians, who hold the simple humanity of Christ; from Michael Servetus, a celebrated professor of those opinions, who was burnt to death at Geneva, by the orders of the magistracy of the republic, under the influence of Calvin, in 1553.

Servile. A Spanish political nickname; applied, in the first instance, to those who opposed the changes advocated by the liberal party in the cortes of 1808 and the following years.

Servites (servants of the Blessed Virgin). A religious order, instituted in Tuscany in A.D. 1233, under the rule of St. Augustin. The monks wore a black habit, in commemoration of the widowhood of the Virgin. (Mosheim, cent. xiii. part ii.)

Servitor (Lat. from servio, *I serve*). An undergraduate, who is partly supported by the college funds, is so called at Oxford. The servitors at Oxford correspond to the sizars at Cambridge.

Servitude (Lat. servitudo). In the Civil Law, servitude is divided into real or predial, mixed, and personal: the first being the subjection of an inheritable thing to certain duties or services towards another inheritable thing; the second that of an inheritable thing towards a person; the third, that of a person towards a person or thing, i.e. slavery, whether by dependence on a person or on the soil. The word *servitude* is equally applicable to the duty or burden, and to the right of exacting it: e.g. the right of way which A enjoys on the land of B, and B's liability to permit that right to be exercised, are both designated by the term *servitude*; the first active, the latter passive. Real servitudes are numerous, and fall into several classes or divisions. They are, for example, either *visible*, such as the right to light and air, sewers, &c., or *latent*, such as the right of way, right of drawing water, &c., which appear only when they are exercised. They were also divided by the Romans into urban, which affected dwellings in the city; and rustic, appertaining to land and farm building. Of mixed servitudes only three species were recognised by their writers on jurisprudence—usufruct, use, and habitation.

Servitude, Domestic. [SLAVERY.]

Servius Tullius. As the name of Romulus, the first of the traditional kings of Rome, has been included in the list of mythical personages noticed in this work, the interests of historical truth seem to require the admission that the last of the Roman kings is scarcely less mythical than his predecessors. The history of Servius is made up either of prodigies and marvels, or of plausible fictions of the kind which De Foe turned to such good account in his life of Robinson Crusoe. In one version, Servius is the son of a god, born of a slave named Ocresia; soon after his birth his mother saw his head enveloped in flames; when she awoke him the fire was extinguished. Niebuhr rejects this story as a mere contrivance to account for his name, which, he affirms, has nothing to do with slavery, but denotes a child born (sero, *late*) in the *evening*, as Manius means one born (mane) *in the morning*. Another account makes him the posthumous son of a chieftain slain in defending Corniculum against Tarquin. The emperor Claudius, on the other hand, in a speech preserved on a brazen tablet at Lyons, asserted that Servius was not a Latin at all, but an Etruscan, his real name being Mastarna; that he came to Rome with Cœlius Vibenna, and, settling with him on the Cœlian hill, changed his name to Servius Tullius. But Cœlius is the mere eponym of the hill which bears the name, as Orchomenos and Phigaleus are mere eponyms of Arcadian towns; and we have no means of knowing whence the emperor Claudius derived his information, nor is there any ground for believing that the Etruscans possessed an authentic historical literature. The legend in Livy represents him as succeeding to the throne while quite a young man; but almost immediately he has children old enough to be married to the children of Tarquin. So, again, Servius is said to have been murdered by the second Tarquin when the latter was a young man; but if this Tarquin was, as he is represented, the son of Tanaquil, he must have been 70 years old when he became king on the death of Servius, 95 when he was expelled, and 110 at his death. The story of his murder is a topographical legend to account for the name of the Vicus Sceleratus or the Accursed Street. This tale, in the belief of Niebuhr, formed part of a great epic poem lost before the time of

contemporary historians. Of such a loss we have no evidence whatever.

The element of plausible fiction comes in with the description of the Servian constitution. The contradictions which run through the whole account of the motives and character of the change are pointed out by Sir Cornewall Lewis, who admits the *possibility* that 'there may have been some historical ground, resting on a faithful official tradition, for connecting the name of Servius with an arrangement of the census; but there is no sufficient reason for believing him to have been the author of the matured and complex system which is presented to us as his work, or for supposing that the authorship of it is ascribed to him in any other sense than that in which Romulus is said to have founded the senate, Numa the ceremonial law, and Tullus Hostilius the law of the Fetiales.' (*Credibility of Early Roman History*, ch. xi. § 30.)

Sesamoid Bones (Gr. σησαμοειδής, *like sesame-seeds*). Small bones developed at or near the articulations of joints are so called by reason of their somewhat bean-like form. The term is also often given to the ossifications which are found in various tendons attached to the long bones. The *patella* or knee-cap is the largest of the sesamoid bones in man.

Sesamum (Lat.; Gr. σήσαμον). A genus of plants of the natural family *Pedaliaceæ*. They are supposed originally to have been natives of India; but are now cultivated in many countries. Their seeds, which are employed as an article of diet, yield an oil of a very fine quality, which, under the name of Gingelly oil, forms an extensive article of commerce in the East. When of good quality this oil is used for adulterating oil of almonds. All the species are annuals.

Sesbania (Arab. sesban). A genus of Leguminous plants consisting of shrubs or shrubby annuals dispersed over the tropics of both hemispheres, having pinnate leaves, the leaflets of which often possess the irritable nature of the well-known sensitive plant.

The Danchi of India, an erect slightly branched annual, is cultivated for its fibre, which, though coarse, is of great strength and very durable in water or when repeatedly wetted, and is consequently valuable for the ropes of fishing-nets, &c.; but it is not suitable for ship's cordage, as it contracts very much when wet.

Sesia (Gr. σής, *a moth*). The name of a genus of Lepidopterous insects.

Sesostris. A legendary or mythical king of Egypt. According to Herodotus, he was a son of Mœris, the eponym of the lake which bears the name, and reigned in the eleventh century B.C. According to Manetho, he is the third king of the twelfth dynasty, reigning in the fourth millennium B.C. In Diodorus, seven generations intervene between Mœris and Sesoosis, or Sesostris, of whom he professes to give an account more authentic than that of Herodotus. The dynastic schemes set forth by these and other writers are contradictory throughout; and Sir G. Cornewall Lewis (*Astronomy of the Ancients*, 347) especially notes 'that these discordant schemes all profess to be derived from the same authentic source. They cannot be reconciled by any legitimate method of criticism, and yet there is no satisfactory ground for preferring one to another. We are not entitled to assume that any one of our authorities was intentionally deceived by the priests, or that he reported or transcribed his information incorrectly. Having, therefore, no sufficient reason for selecting any one of these systems, we are compelled, by the laws of historical evidence, to reject them all.'

The stories told by Herodotus of Sesostris are assigned by other writers to kings who are named Sesoosis, Sesonchosis, Gosormies, &c. The process by which Egyptologists profess to reconstruct his true history is confessedly analogous to the method applied by Niebuhr to the early history of Rome. The Sesostris of Manetho is clearly the same as the Sesostris of Herodotus; but the dates differ by about 2,000 years. 'Bunsen,' remarks Sir G. C. Lewis, 'first takes a portion of him, and identifies it with Tosorthrus (written Sesorthus by Eusebius), the second king of the third dynasty, whose date is 5119 B.C., being a difference in the dates of 1,799 years, about the same interval as between Augustus Cæsar and Napoleon. He then takes another portion and identifies it with Sesonchosis, a king of the twelfth dynasty; a third portion of Sesostris is finally assigned to himself. It seems that these three fragments make up the entire Sesostris who in this plural unity belongs to the ancient empire; but it is added that the Greeks confounded him with Ramesses, or Ramses, of the new empire, a king of the nineteenth dynasty, whose date is 1255 B.C., who again was confounded with his father Sethos, which name again was transmuted into Sethosis and Sesosis. Lepsius agrees with Bunsen that Sesostris on the Manethonian list, who stands in the twelfth dynasty at 3320 B.C., is not Sesostris, but instead of elevating him to the third dynasty, brings him down to the nineteenth dynasty, and identifies him with Sethos, 1326 B.C., chiefly on account of a statement of Manetho, preserved by Josephus, that Sethos first subjugated Cyprus and Phœnicia, and afterwards Assyria and Media, with other countries farther to the East. . . . . We therefore see that the two leading Egyptologists, Bunsen and Lepsius, differing in other respects, agree in thinking that Sesostris is not Sesostris. . . . But here their agreement stops. One assigns Sesostris to what is called the old, the other to what is called the new empire, separating his respective dates by an interval of 3,793 years. What should we think if a new school of writers on the history of France, entitling themselves Francologists, were to arise, in which one of the leading critics were to deny that Louis XIV.

lived in the seventeenth century, and were to identify him with Hercules, or Romulus, or Cyrus, or Alexander the Great, or Cæsar, or Charlemagne, while another leading critic of the same school, agreeing in the rejection of the received hypothesis as to his being the successor of Louis XIII., were to identify him with Napoleon I. and Louis Napoleon?' (*Astronomy of the Ancients*, 370.)

Sesqui (Lat.). This prefix, applied to words, signifies one integer and a half; as sesqui granum, *a grain and a half*, &c. In Chemistry, this term is used to designate compounds in which an equivalent and a half of one substance are combined with one of another; thus, sesquicarbonate of soda is a salt composed of one equivalent and a half of carbonic acid with one of soda.

Sesqui. In Geometry, the expression of a ratio in which the greater term contains the less once, and leaving a certain aliquot part of the less over. Thus, if the part remaining is half the less term, the ratio is called *sesquialtera*; if the part remaining be a third of the less term (as in the ratio of 4 to 3), the ratio is called *sesquitertia*, and so on. These terms are nearly obsolete. *Sesquiduplicate*, however, sometimes occurs in modern treatises, and signifies the ratio in which the greater term is twice and a half times the less; as the ratio of 10 to 4, or of 15 to 6.

Sesqui. In Music, a whole and a half; which, joined with *altera*, *terza*, *quarta*, &c., is much used in the Italian music to express a set of ratios, particularly the several species of triple time.

Sessiles (Lat. sessilis, from sedeo, *I sit*). The name of a division of the class *Cirripeds*, comprehending those species which are not suspended by a pedicle.

Session, Court of. The supreme civil court of Scotland, having jurisdiction in all civil questions, of whatever nature. It was constituted by an Act of the Scottish parliament in 1537. It was intended to supply the place of the previously existing courts, and more especially of a judicial committee of parliament called the 'lords of session;' whence the name of the court and the titles of the judges. Originally it consisted of seven laymen and eight churchmen, including the president. In 1640, however, an Act was passed providing for the exclusion of churchmen from the court; and though repealed in 1661, the principle laid down in it has ever since been acted upon. Other important improvements were introduced at different periods, particularly after the Revolution, when the right of appeal from the court to parliament was, for the first time, recognised. At the Union, power was given to all individuals who considered themselves aggrieved by judgments of the Court of Session to appeal to the House of Lords; and for a lengthened period a large portion of the judicial business of the House of Lords has consisted in hearing and deciding Scotch appeals. Originally, and down to 1808, the whole fifteen judges sat together in one court; but in that year an Act was passed dividing the court into two chambers, the lord president presiding in the first division of seven judges, and the lord justice-clerk in the second of six; the two remaining judges trying cases in the first instance, or, as it is technically termed, sitting as lords-ordinary. Since that time the number of judges has been reduced to thirteen; four belonging to each of the divisions, and five acting as lords-ordinary. The judges were at first chosen by the Scotch parliament; but since 1554 they have been appointed by the crown. They are either, as already stated, called lords of session, or senators of the college of justice; which last embraces the whole body of barristers (advocates) and attorneys or solicitors who practise before the court. They must be twenty-five years of age; and, by the Treaty of Union, no person can be named to the office unless he have served as an advocate or principal clerk of session for five years, or as a writer to the signet for ten. The salaries of the ordinary judges are 3,000*l.* a year each; those of the lord justice-clerk and lord president being respectively 4,500*l.* and 4,800*l.*

At its outset, the Court of Session was intended to serve as a standing or perpetual jury for the trial of cases; the introduction of petty juries into the trial of civil cases in Scotland being only of very recent date, as well as of limited application. It was, in fact, unknown till 1815, when a special or jury court was instituted, for the trial of cases involving questions as to the value of property, or damages, or the determination of some fact. But in 1830 this court was suppressed, and the Court of Session now avails itself of the assistance of petty juries in the trial of the above description of cases. [Justiciary, Court of.]

Session of Parliament. The period between its meeting and prorogation. All the Acts passed in a session are legally considered as forming a single statute; each separate Act being designated as a chapter, and its subdivisions as sections. [Parliament.]

Sessions, Great, of Wales. A local court of the principality of Wales erected by stat. 34 & 35 Hen. VIII. c. 26, with a local jurisdiction similar to the general jurisdiction in England of the Court of Common Pleas. But by stat. 2 Geo. IV. and 1 Wm. IV. c. 70 the Court of Great Sessions was abolished, and the jurisdiction of the courts of Westminster was extended to Wales.

Sessions of the Peace. In English Law, the term *session of the peace* is applied to designate a sitting of justices of the peace for the execution of those duties which are confided to them by their commission, and by charter or statute. Such are: 1. A petty (or petit) session, which is a private meeting of two or more justices of the peace for the execution of some power vested in them by law; many Acts of Parliament requiring the concurrence of a plurality of justices, and there

being other occasions on which, although not strictly necessary, it is considered usual and expedient. One of the most important instances of the first kind is the holding parties to bail against whom a charge of felony has been entertained. 2. A special session, which is principally distinguished from the former by being public, instead of on the private motion of the justices, it being necessary that notice should be given to every magistrate of the division. Special sessions are held to grant licenses, execute the provisions of the Highway Act, appoint overseers of the poor, and for many other purposes. 3. Quarter sessions. [JUSTICE OF THE PEACE; QUARTER SESSIONS.]

Sestertium (contracted from mille sestertiorum). The sum of 1,000 sestertii; usually estimated at about 8*l.* English.

Sestertius (Lat. an abbreviation of semistertius, *two and a half*). A sesterce; a Roman silver coin, equal in value to two *asses* and a half, or nearly twopence of English money.

Set Fair. In Architecture, the coat of plaster used after roughing in and floated, or pricked up and floated. It should be well trowelled, to answer well for colour.

Set Off. In Architecture, the horizontal projection left in carrying up a wall, where the thickness of it diminishes at its different stages or stories.

SET OFF. In Law, a species of defence to a civil action, by which a party acknowledges the justice of the plaintiff's demand, but sets up a demand of his own against the plaintiff sufficient to counterbalance either the whole or a part of it.

Seta (Lat. *a bristle*). In Botany, the term applied to a bristle of any sort; a stiff hair; a slender straight prickle; also the stalk which bears the spore-case of mosses and allied plants.

Setaceous (Lat. seta). In Entomology, the antennæ which resemble a bristle are so called.

Sethians. In Ecclesiastical History, a sect of Egyptian Christians, who sprang up in Egypt in the second century. Their chief peculiarity consisted in their belief in the identity of Jesus Christ with Seth, the son of Adam, whence they derived their name. They continued to exist about 200 years.

Seticers (a word coined from Lat. seta, *a bristle*; and Gr. κέρας, *a horn*). A term applied by Latreille to a family of Lophyropodous Crustaceans, including those in which the superior antennæ are long and setaceous.

Setigers (Lat. setiger, *bristly*). The name of a tribe of Annelidans, including those which, like the earthworm, are provided with bristles for progressive motion. The *Setigera* are the first tribe of the Abranchiated order of Annelidans.

Setiremes (Lat. seta, *a bristle*; remus, *an oar*). A name given by Kirby to the natatory legs of certain aquatic insects, which are fringed with bristles.

Seton (from Lat. seta, *a bristle*; because bristles or horse hairs were formerly used to keep open the wound). A seton is an artificial ulcer, made by passing a skein of thread under a portion of the skin by means of an instrument called a seton needle: the thread is occasionally anointed with irritating substances, in order to keep up a discharge from the sore.

Setose (Lat. setosus, *bristly*). In Botany and Zoology, when a surface is beset with stiff scattered hairs.

Settee. A two-masted lateen-rigged vessel formerly used in the Levant, but now extinct, or nearly so.

Setter. A variety of spaniel, which has been taught to couch down (technically termed *set*) on the sight of game, this habit distinguishing it from the *pointer*, which dog on seeing the birds becomes stationary in the position in which he may be at the moment. The *setter* is closely allied to the water-spaniel or barbet.

Setting. In Architecture, the term *setting* is applied in the sense of the hardening of cements, limes, or plasters. It also means the fixing of the stones in walls or vaults.

Setting Coat. In Architecture, the best sort of plastering on ceilings or walls; in inferior work it is made of *fine stuff*, and when the work is very dry a little sand is used. A setting coat may be either a second coat on laying or rendering, or a third upon floating. The term *finishing* denotes the third coat, where stucco is used; that of *setting*, where the work is for paper.

Settlement. In Law, the right which an individual acquires to parochial assistance, under the statutes for the relief of the poor, in that parish or district to which he legally belongs, and in which he is said to have the settlement. [POOR LAWS.]

Settlement, Act of. The statute 12 & 13 Wm. III. c. 2, which vested the succession to the crown, after the death without issue of King William III. and Queen Anne, upon the Princess Sophia (being the youngest daughter of Elizabeth, queen of Bohemia, who was the daughter of James I.) and the heirs of her body being Protestants.

Settlement of Property. By the English Law, the unsettled fortune of a wife is placed very much in the power of her husband, and the rules regulating the transmission of property among married persons and their issue are in other respects found to be practically unsuited to the requirements of families. It has therefore become usual, whenever circumstances will admit, to make arrangements previously to a marriage, to secure some certain provision for the wife and children, and to protect the family property against the effects of extravagance, misfortune, or caprice. The instruments by which these arrangements are carried out are known as *marriage settlements*, and vary to some extent in each particular case, though the same general form is usually followed. Stock or other personal property is usually vested in

trustees and settled upon the husband and wife successively for life (the wife if she takes the first life interest being protected against the control or engagements of the husband), and after their deaths upon trust for all or any of the children as the husband and wife or the survivor of them may appoint, and in default of appointment upon trust for the children equally (sons at twenty-one, daughters at twenty-one or marriage). Real estate of small value is usually directed to be sold and the proceeds settled as personalty, for property of this nature cannot be advantageously enjoyed in specie in undivided shares. Real estates of considerable value are usually settled upon the husband for life, often with an annual allowance for the wife by way of *pin money*. Provision is then usually made for payment of a jointure to the wife, if she survive her husband, and for raising portions for the younger children, subject to which the estates are entailed upon the sons of the marriage and their issue successively, with remainder to the daughters and their issue.

Settlements of property are often made on other occasions than that of marriage, and are then known as *family settlements*. Settlements of estates by way of entail are known as *strict settlements*, and often contain limitations carrying the estates to the collateral branches successively of a family, clauses compelling the assumption of a particular name, or of arms, and other complicated provisions. As, however, the first tenant in tail, who is usually the eldest son of the first tenant for life, can on attaining twenty-one (with the consent of the tenant for life if living) bar his estate tail and all subsequent estates or interests, it rarely happens that all the limitations of a settlement are allowed to fall successively into possession; and, as a matter of fact, the great estates in this country are usually re-settled in every generation, and often as soon as the eldest son of the landowner in possession attains majority. In settlements of all kinds it is necessary to insert numerous powers and clauses with respect to investments, leases, sales, and other particulars relating to the management of the settled property, much prolixity being thus occasioned. There is little doubt that the continued repetition of these provisions might be dispensed with by a suitable amendment of the law, but an attempt which has been recently made in this direction has not proved very successful (stat. 22 & 23 Vict. c. 35).

Seven Years' War. In History, a war carried on in Germany between two alliances, headed respectively by Austria and Prussia, from the year 1756 to 1763, when it was ended by the peace of Hubertsburg. It was signalised chiefly by the extraordinary campaigns of Frederick II. king of Prussia. His principal ally throughout the struggle was England; while he was, at one period, assailed by the forces of Austria, France, the Empire, Sweden, and Russia. When the forces of the Prussian sovereign had been almost annihilated by this coalition, the death of the Russian empress, Elizabeth, caused the withdrawal of Russia from the alliance of his enemies, and thus brought about the termination of the war.

Seventh. In Music, an interval, of which there are three species. First, the diminished seventh, consisting of nine semitones, as from C♯ to B♭. Second, the minor seventh, consisting of ten semitones, as from C♮ to B♭. Third, the major seventh, being only a major semitone less than the octave, as from C to B♮.

Severite. A variety of Halloysite, somewhat resembling Lithomarge. It is a hydrated silicate of alumina, found in small masses, from two to five inches in diameter, in Tertiary deposits at St. Sever in France.

Sewage. The drainage water of towns, including all sorts of house waste. Since the adoption and extended use of water-closets, the waste water of towns has become more offensive than, in the old days of privies and cesspools, it used to be; and enactments are now being levelled against the increasing consequent pollution of rivers. The agricultural utilisation of this filthy drainage water is the true remedy for all the evils complained of. The soil deodorises the water poured over it, which flows off purified, leaving behind it as the food of plants those ingredients whose putrefaction would have poisoned the air. Its leading fertilising ingredient is nitrogen in some of the many forms which by decomposition yield ammonia. Sewage generally yields ammonia at the rate of about seven grains in a gallon, or 1 in 10,000 of weight. This extreme dilution forbids all hope of extracting the valuable part of town drainage water except by employing a growing plant for the purpose; and the use of the liquid, as of water in irrigated meadows, by letting it flow over the surface of grass land, seems to be the best or indeed the only method of turning it to useful and profitable account. In this way 100 to 150 tons of sewage may produce a ton of grass; and as that near towns is worth 18*s.* to 1*l.* per ton, we get 2*d.* per ton as, under ordinary circumstances, the total value of the sewage water of towns. For the expense of hiring land and labour in the process we must, however, deduct one-half to three-quarters of the whole receipts, so that if ultimately towns shall obtain ¼*d.* to ½*d.* a ton for their drainage stuff as a contribution towards their expenditure and sewers, the result must be considered satisfactory. In the first instance, the risk of the venture being considerable, the only arrangement possible with any company who should propose to take the sewage for agricultural use is that either of simple gift for a term of years, or of reserving an ultimate share in the profits after they have been realised.

It is proper to add, that no one has yet succeeded in extracting 2*d.* per ton from sewage; but there seems reason to expect that better and more economical field arrangements may

yet succeed in realising the anticipations of the theorist. Taking guano at 7*l*. 14*s*. per ton, and 828 tons of sewage equal in fertilising power to a ton of guano, Liebig reckons that the sewage of London is worth 1·84*d*. per ton, or has an annual value of 15*s*. 4*d*. per head of the population, 100 tons of sewage per annum being considered as about the amount of sewage due to each individual. Dr. Hoffmann's estimate does not differ much from this. He considers the sewage to be worth about 2*d*. per ton, or to be worth 17*s*. 7*d*. per head of the population; and taking the population at 2,600,000, the bulk of sewage annually discharged by the sewers would be 266,000,000 tons, and its annual value 1,385,540*l*. Estimates of value not widely differing from these have been given by Voelcker, Sir C. Fox, Hope, Lawes, Ellis, Mechi, and others. Many expedients for deodorising sewage have been propounded, but none of them generally adopted, and the conviction seems now to be that the soil itself is the best deodoriser. Nor is there yet much agreement as to the best modes of applying sewage to land. On the whole, the best plan seems to be to apply it in the same way in which water is applied to irrigate the fields. The sewage may be run over the fields, which should be divided into beds some 50 yards wide, with a slope of 1 in 120, or thereabout; so that, carried along the ridge line of the beds, it may trickle down their sides to the furrow which will act as a surface drain, and carry it to where it may be again used on a lower level.

Sewer. In Architecture, a subterraneous conduit, or channel, to receive and carry off the superfluous water and filth of a city. The sewers of Rome have been the models of those of the modern cities of Europe. The cloacæ had, between the Quirinal, Capitoline, and Palatine hills, many branches, which joining in the Forum, now the Campo Vaccino, were received for conveyance into the Tiber by a larger one, called the *cloaca maxima*. It must be admitted, however, that it is erroneous to designate the Roman cloacæ by the term sewers. They were rather drains, made to carry off the stagnant water of the pestilential marshes which occupied much of the low ground near the Tiber, and the spaces between the Aventine, Palatine, and Capitoline hills. The height and width of the cloaca maxima are equal, each measuring 13½ feet.

Arched drains or sewers have been found in the ruins of Assyrian cities. In modern sewers, which are built of brick set in cement, the section is generally made of an egg form, with the smallest end downward, with a view of obtaining the necessary strength against compression, and of narrowing the surface of the stream of sewage, as it becomes shallower, so as better to maintain the scouring action due to its velocity, and thus to diminish deposits which would virtually convert the sewer into a long cesspool. The effect of improving the sewerage of towns has been to pollute the rivers into which the sewers discharge to such an extent, that it has been necessary in London and in some other large towns to construct intercepting and transmitting sewers of large size, which transmit the sewage to a point of the river sufficiently near the sea to get rid of it without offence. The intercepting sewers, like catch-water drains, receive as much of the sewage as can be collected at the level which is necessary to transmit it by gravity to its destined outlet; and the portion which cannot be thus transmitted is collected by a sewer at a lower level, and after having been conducted sufficiently far along the banks of the river to be clear of the town is pumped by steam engines or otherwise up to the higher level, where it can be disposed of in common with that transmitted by the intercepting sewer. But many are now of opinion that the whole system of the sewerage of towns is constructed upon an erroneous principle, since the sewers are, in fact, made to fulfil two separate functions, the proper discharge of which is impossible in a single system. The original function of the sewers of most existing towns was to carry off the rain which fell on the streets and houses into the nearest river. But the changes introduced into the domestic arrangements of our houses during the present century, have superadded the function of transmitting such refuse to that of transmitting the mere surface water. Now, as rain falls at irregular times, and sometimes in very large quantities, the sewers require to be large to be able to transmit this large volume of water; and in dry weather, but for the sewage proceeding from the houses, the sewers would be empty and dry. The small stream of sewage, however, requiring at such times to be transmitted does not flow at a sufficient velocity to carry on all the matters suspended in it, and the sewers thus virtually become long and high cesspools with a thick deposit of fetid mud at the bottom. In heavy rains no doubt a large part of this deposit is swept out; but this action leads to the further evil that the volume of sewage becomes at these times so great that it is difficult to deal with it, since the transmitting and distributing capabilities of any conduits employed to lead it away must be made equal to the greatest pressure which is likely to be put upon them on the worst occasions. These evils point to the propriety of having two systems of sewers in towns, of which one (best formed with clay or iron pipes) shall be devoted to the single purpose of transmitting the sewage of the houses to some appropriate terminus; and as this sewage is not large in volume, and is nearly uniform in quantity, the dimensions of such sewers need not be great. The ordinary sewers would thus be restored to their primary function of transmitting the surface waters alone, and these waters might be conducted into the nearest river without sensibly polluting it. This system was tested and advocated by Mr. Simpson, of Edinburgh, about 1340; but al-

though it has often been since advocated by others, it has not yet been adopted. The quantity of sewage yielded by a town would be approximately measurable under this system by the quantity of water delivered to it, according to which the sizes both of the water pipes and sewer pipes should be computed, whereas the dimensions of the sewers for transmitting the surface water would be properly measurable by a reference to the maximum rainfall in a given time, and the area of ground from which the water had to be conducted. For further information, see SEWAGE; and also reports made to the Metropolitan Board of Works; Hellerstedt's Paper on the Paris Sewers; Reports by Messrs. Hawksley, Wickstead, Bateman, &c., on the sewerage of various towns in England, and Reports published by the General Board of Health.

Sewers, Commissioners of. These commissioners have been appointed by the crown from very early periods to enforce the law relating to the defences of the land against the sea, and inundation by land floods and to the free course of navigable rivers. The law on the subject was extended and settled by the statute of Sewers (23 Hen. VIII. c. 5), and many subsequent Acts have since been passed. The commissioners are a court of record, and may fine and imprison for contempts, and have various powers of levying rates. The Land Drainage Act of 1861 contains some important provisions on the subject.

Sewing Machine. Sewing machines have been divided into four classes. In the first, the needle is passed completely through the stuff, as in hand-working; but this method, adopted naturally in the infancy of the invention, has been generally abandoned. The sewing machines of the second class are known as the chain-stitch or *crochet* machines, wrought by a so-called crochet needle, which terminates with a hook. In the third class, the machines are wrought by two threads, the stitch produced by them being known in America as the mail-bag stitch. The fourth class of sewing machines produce more complex stitches, which are formed by sewing two threads, mutually interlacing each other in chain stitch, so as to avoid the unravelling to which the simple chain stitch is subject. For a description of these several classes of machines, the reader is referred to the art. 'Sewing Machines' in Ure's *Dictionary of Arts, Manufactures, and Mines.*

Sexagesima (Lat. *sixtieth*). In the Calendar, the eighth Sunday (nearly sixty days) before Easter.

Sexagesimal Arithmetic. A method of computation proceeding by sixties (as the common arithmetic proceeds by tens), and used by the ancient Greek astronomers for facilitating arithmetical calculations, particularly division and the extraction of roots; operations which, when performed on numbers expressed by the complicated Greek notation, are attended with great labour and difficulty.

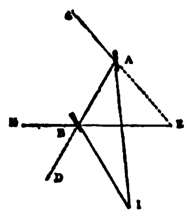
Sexagesimal Fractions. In Arithmetic, such fractions as have 60, or some multiple of 60, for their denominator. Fractions of this kind were anciently the only fractions used in astronomy; and they are still retained in the division of the circle, and of time, where the degree, or hour, is divided into sixty minutes, the minute into sixty seconds, and so on.

Sextans or **Sextant.** In Astronomy, one of the constellations formed by Hevelius. It is placed across the equator, and on the south side of the ecliptic.

Sextant (Lat. sextans, *the sixth part*; the limb of the instrument being the sixth part of a complete circle). An instrument for measuring the angular distances of objects by reflexion. The sextant is capable of very general application; but it is chiefly used as a nautical instrument for measuring the altitudes of celestial objects, and their apparent angular distances. It is an instrument of the utmost importance in navigation.

The principle of the sextant, and of reflecting instruments generally, depends upon an elementary theorem of catoptrics; viz. if an object be seen by reflexion from two mirrors which are perpendicular to the same plane, the angular distance of the object from its image is double the inclination of the mirrors. Thus, let A and B be sections of two mirrors perpendicular to the same plane, and inclined to each other in the angle A I B; a ray of light coming from the sun and falling upon the mirror A, in the direction S A, will be reflected in the line A B; and falling upon B, it will again be reflected in the direction B E. Let A B be produced to D, and S A prolonged to meet B E in E. Now, since the angles of incidence and reflexion are always equal [REFLEXION], we have D B E = 2 D B I, and B A E = 2 B A I; but D B E = B A E + B E A, and D B I = B A I + B I A, consequently B A E + B E A = 2 B A I + 2 B I A; and therefore, since B A E = 2 B A I, we have also B E A = 2 B I A; that is to say, the angular distance between the object S and its image seen by the eye at E, in the direction E B H, is the double of the inclination of the mirrors. It may be remarked, that the place of the image, as seen from E, is independent of the situation of the mirrors on the plane, so long as the line of the intersection of their planes and their inclination to each other remain constant.

Fig. 1.

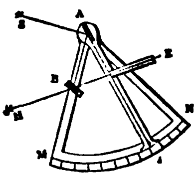


From what has been now said, it may be seen that if a convenient method could be devised for measuring the inclination of two mirrors perpendicular to the same plane, when they are so placed that the image of an object S is brought to coincide with an object H seen directly, we should at once have a reflecting instrument for measuring angular distances.

Such instruments are the *sextant*, the *quadrant*, the *reflecting circle*, respectively so called from the extent of the arc which the graduated limb embraces.

The contrivance adopted for this purpose in the sextant is to attach the frame of the mirror B to the plane of the sector of a circle A M N, and the frame of the mirror A to a radial bar A I revolving in the plane of a sector round a pin passing through the centre. Both frames are generally supplied with the means of adjusting the planes of the mirror vertically, and B is generally also capable of being turned by a delicate motion a small way round a pin passing through the frame of the sector.

Fig. 2.



The arc or *limb* M N of the sector is graduated; and the revolving radius or *index* carries at its extremity a vernier scale, applying to the graduations on the limb, and subdividing them into such smaller portions as may be desired.

The method of finding the zero point of the limb may be understood generally from the following considerations: The angle E (fig. 1) being double the angle I, it follows that when the mirrors are parallel, or the angle I is nothing, the angle E is nothing also, and S and its image will appear as one object, the one exactly covering the other. It is therefore only necessary to turn round the radial bar which carries A till the image of a distant object seen by reflexion from B is in accurate conjunction with the object itself, seen directly; and the point on the limb at which the index then stands is the zero point of the arc. If it is not also the zero of the numbered graduations, its distance from the numeral zero is called the *index* error of the instrument, and is to be applied as a correction to all angles measured.

In graduating the limb, half degrees are marked as whole ones, and the smaller divisions accordingly; so that the angle read from the instrument is not the inclination of the mirrors, but the distance of the object from its image. In this class of instruments, therefore, 90° are indicated by an arc of 45°, 120° by an arc of 60°, &c.

The mirror A is completely silvered behind; but B is silvered on that half only which is next the plane of the instrument, the upper part being left clear, that objects, such as H, may be seen *through* the upper portion of it, as well as the images of others, as S, by reflexion *from its lower, silvered, surface*. The mirror B is so placed by the maker that when A is parallel to it, the index, which carries A, either exactly or nearly corresponds with the zero of the divisions as they are numbered on the limb. When the index has been set by hand nearly in the position requisite for measuring any proposed angle, it is clamped to the limb by a screw acting on a spring, and moved slowly by a tangent screw till it attains accurately the required position.

Such being the general principles of the instrument, we shall now briefly describe the different parts of it, as constructed by the best makers, and the methods of adjusting and observing with it.

The only important object to be aimed at in the frame is to combine lightness with sufficient strength.

The telescopes used are of two kinds. One, a direct telescope, which is simply an opera-glass; and having a narrow field of view, is generally used in the more ordinary sort of observations, such as observing altitudes. The other is an inverting or astronomical telescope. In the frames of each eye-piece are two pairs of wires, each pair perpendicular to the other, dividing the field of view into nine spaces, of which that in the middle is square; and it is important that in all observations made with this instrument the contact of the image seen by reflexion, and of the object seen directly, should be made as near the middle of this square as possible, at any rate at the same distance as the centre of the square from the plane of the instrument.

It is essential, also, that the telescope should be parallel to the plane of the instrument; and in the collar into which the telescope is screwed there are two screws for making this parallel adjustment. The adjustment is not very liable to alter, but no careful observer will omit to examine it at every convenient opportunity.

Both the mirrors are supplied with coloured glasses of different degrees of shade, framed and placed in such a position that they can be turned down before the mirrors, either singly or combined. The eye-pieces of the telescopes are also supplied with coloured shades, set in caps, which are screwed on the eye-piece. They are used in taking the index error by means of the sun, and in observing the sun's altitude from an artificial horizon.

Adjustment of the Sextant.—1. To set the index glass, when it admits of adjustment, perpendicular to the plane of the instrument.

Place the index about the middle of the limb; and looking obliquely into the index glass, the part of the limb will be seen by reflexion in the glass, as well as directly. If the part of the limb seen directly and its image in the glass appear as one continued frame, the mirror is in adjustment; but if the reflected image appears to incline downward, it shows that the face of the glass inclines backward from the perpendicular; if upwards, that it inclines forward, and the adjustment must be made by the screw supplied for the purpose.

2. To set the horizon glass perpendicular to the frame of the instrument.

Having carefully adjusted the index glass, or seen that it is in adjustment, screw the telescope into its socket; adjust the eye-piece to distinct vision; screw the dusk shade cap on the eye end of the telescope, or turn down

shades before the mirrors; and looking towards the sun, bring the index near to zero; move it steadily backwards and forwards, and the reflected image of the sun will be seen to pass over his disc, as viewed directly. If the two circular discs accurately cover each other in passing, the perpendicular adjustment of the horizon glass requires no adjustment; but if they pass a little aside of each other, so that two different-coloured lines appear on each side of the overlapping middle part, the mirror B must be turned by the appropriate screw till the discs accurately cover each other, when the adjustment will be complete. This adjustment may also be effected by making a bright star and its image coincide with each other; but in this case it is scarcely necessary to say that the darkening shades must be turned aside.

3. To set the telescope parallel to the plane of the instrument. This adjustment is effected by two screws in the collar which attaches the telescope to the limb of the sextant, diametrically opposing each other in a line perpendicular to the plane of the instrument. By tightening the upper one the object end of the telescope is inclined towards the instrument, and the contrary effect is produced by tightening the lower one. To make the adjustment, turn round the eye-piece of the telescope till two of the wires in its focus appear parallel to the plane of the instrument (and of this the eye can judge with sufficient accuracy); then take two objects, as two bright stars, or the sun and the moon, whose distance in either case should not be less than 90°, in order that any error in the adjustment may become more apparent, and bringing the image of one of the objects in accurate contact with the other object on the wire next the instrument, *instantly* bring them to the other wire; and if they are also in accurate contact upon that wire, it may be concluded that the axis of the telescope is parallel to the plane of the instrument. If the objects are the sun and moon, and they separate at the farther wire, it shows that the object end of the telescope inclines towards the plane of the instrument, and the contrary if they overlap; and the error must be corrected by turning the proper screws in the collar.

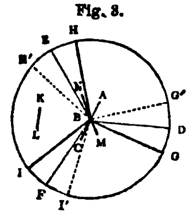
The index error of the instrument may be most conveniently and accurately determined, as follows. Having effected the perpendicular adjustment of the horizon glass by the method above explained, bring the border of the sun's reflected image to coincide with the sun seen directly both on the right and left side; and, reading the index at both observations, if one reading is on the left and the other on the right of zero, *half the difference is the index error*, and the fourth part of the sum is the sun's semidiameter; but if both readings are on the same side of zero, *half the sum is the index error*, and the fourth part of the difference is the semidiameter.

The Reflecting Circle depends on the same principles as the sextant, from which it differs chiefly by having the whole circle graduated. In some instruments of this kind the angle is measured by repetition. [REPEATING CIRCLE.]

But the only instrument of this kind that can be now said to be in general use in this country is Troughton's reflecting circle; in which, by means of three equidistant indexes, and by observing alternately with the face of the index direct and reversed, *six times* the required angle is obtained, without reference to the index correction. After what has been said above on the principles of reflecting instruments generally, the following short account of this instrument will be sufficient.

All the indexes move round together; and, of course, the apparatus for slow motion, or the tangent screw, is requisite only for one of them, which is called the *leading* index, and which, for the sake of convenience, stands at or near zero on the limb when the revolving and fixed mirrors are parallel.

Fig. 3.



In the annexed figure let B D, B E, and B F be the positions of the indexes when the revolving mirror is parallel to the fixed one K L; and let A C and M N be two positions of the revolving mirror when it is equally inclined to K L. Then the arcs D G, D G′, E H, E H′, F I, F I′, passed over by B D, B E and B F, will be all equal; and if, when the mirror has the position M N, the face of the instrument be reversed, M N and K L will have the same relative position to each other that A C and K L have; and consequently if an object is seen by reflexion from A C and K L, it will also, when the instrument is reversed, be seen by the reflexion from M N and K L to an eye placed in the same situation. Hence the degrees on the arcs G G′, H H′, I I′, which are the differences of the readings of the observations in the direct and reversed positions, are each the measure of double the distance of the object from its reflected image. The degrees being numbered round the circle from 0 to 720°, and the indexes placed very nearly at equal distances from each other, it is customary in practice to read the degrees, with the minutes and seconds, from the leading index only, and to read only the minutes and seconds at the other indexes.

Sextile Aspect. In Astrology, the aspect of two planets when they are distant from each other the sixth part of a circle, or sixty degrees.

Sextinvariant. [INVARIANT.]

Sexton (a corruption of *sacristan*). A church officer, who is properly the keeper of holy things belonging to divine worship, and said to be the same with the *ostiarius* in the Roman church. A sexton is usually appointed for life (whether by the minister or others, according to custom), and in such case a mandamus lies to restore him to his office.

Seybertite. A kind of Clintonite, found

in beds of granular limestone, at Amity in New York.

Sforzato or **Sforzando** (Ital. *forced*). In Music, a term written over a note to signify that it is to be played or struck louder than the rest; it is abbreviated *sf* or *sfz*.

Sfumato (Ital. *smoky*). In Painting, a term applied to that style of painting wherein the tints are so blended that the outline is scarcely perceptible, the whole presenting an indistinct misty appearance. The Milanese painters exhibit this quality more than any others.

Sgraffito or **Sgraffiato** (Ital. *scratched*). In Painting, a species of drawing in which the ground is prepared with dark stucco, on which a white coat is applied; which last being removed with an iron instrument, the scraping it away forms the shadows, giving it the appearance of a chiaroscuro painting. The principal designs of Polidoro da Caravaggio are executed in this manner, which is capable of great effect, and is extremely durable.

Shabrack. The large saddle-cloth, forming part of the full-dress equipment of officers of cavalry and horse artillery. The term is said to be of Hungarian origin.

Shackle. On Shipboard, a ring. The term is applied more especially to the rings of the ports through which the port-bar is passed to close the porthole effectually, and to the ring of the anchor by which it is attached to the cable.

Shad (Ger. schade). A large species of herring, the *Clupea alosa* of Linnæus. It forms a separate genus in the Cuvierian system.

Shaddock. The fruit of the *Citrus decumana*, one of the species of the Orange family. It is said to be named after the person who first carried it from the East to the West Indies.

Shadow (A.-Sax. sceadn, Ger. schatten, Gr. σκότος and σκιά). In Optics, a portion of space from which light is intercepted by an opaque body. As the rays of light proceed in straight lines, every opaque object on which light falls is accompanied with a shadow on the side opposite to the luminous body; and the shadow appears mere intense in proportion as the illumination is stronger, because any object placed within it contrasts more strongly with the surrounding objects on which the light is suffered to fall.

As every point of a luminous body is a separate focus of illumination, it follows that an opaque object illuminated by the sun, or any other source of light which is not a single point, must have an infinite number of shadows, though not distinguishable from each other; and hence the shadow of an opaque body received on a plane is always terminated by a *penumbra*, or partial shadow, the extent of which is greater in proportion to the magnitude of the luminous body, the distance of the opaque body from the plane on which the shadow falls, and the degree of obliquity with which the luminous rays fall on the plane.

Coloured Shadows.—In certain states of the atmosphere the shadows of opaque objects projected on a white surface are frequently observed, about the time of sunrise or sunset, to be of a blue colour. This curious observation appears to have been first made by the celebrated painter Leonardo da Vinci, and is also noticed by Otto Guericke in his *Magdeburg Experiments*; but no further notice seems to have been taken of the phenomenon until about a century later, when it was again noticed by Buffon. Happening to stand on an eminence about the time of sunset, he perceived the shadows of the trees on a white wall about 30 or 40 feet distant to be coloured with a light green, inclining to blue. The next morning, at sunrise, he repeated the observation; but instead of finding the shadows green, he found them blue, or rather the colour of lively indigo. Afterwards he often observed the shadows both in the morning and evening, but always observed them to be blue; and he remarks that any one may see a blue shadow, if he will hold his finger before a piece of white paper at sunrise or sunset. The phenomenon has since been frequently observed, and is now known to be due to the hyper-sensitiveness of that portion of the retina of the eye which receives the image of the shadow, for rays complementary to those which are illuminating the rest of the retina; thus in the *red* glow of evening, a surface in shadow, which is in fact reflecting a subdued light, appears *green*, whilst with a *yellow* light from the rising or setting sun shadows appear *blue*. [COMPLEMENTARY COLOURS.]

SHADOW. In Painting, the form which a solid object projects on a surface or surfaces by being interposed between the surface or surfaces and the sun, or other luminous body. [SCIOGRAPHY.] *Shade* is a term applied to that portion of the object which is not obvious to the luminous body.

Shaft (A.-Sax. sceaft). In Architecture, that part of a column between the base and capital, sometimes called the *trunk* of the column. The shaft of a column always diminishes in diameter from about a third of its height. Sometimes it has a slight swelling [ENTASIS] in the lower part of its height. In the oldest Doric columns, the diminution was so considerable as to give the column a conical appearance. In the Doric edifices at Athens, the upper diameter is not more than a quarter less than the lower diameter; in the temples of Jupiter Nemeus, between Argos and Corinth, not more than a fifth less. In Ionic and Corinthian columns, the difference of the upper and lower diameters varies from a fifth to a twelfth. The ancients seem to have regulated the diminution in some proportion to the absolute height of the column, for no particular law seems to have prevailed in terms of the lower diameter.

SHAFT. In Mechanics, that part of a machine in which the motion is communicated by torsion, as in the paddle-shaft or screw-shaft of a steamship.

SHAFT. In Military Mining, the vertical

excavation made to reach the required position for the charge. Horizontal or inclined excavations are called *galleries*.

Shag (A.-Sax. sceacga). The English name of a species of cormorant (*Pelicanus graculus*, Linn.).

SHAG. A term used in Scotland for the refuse of barley. Also the commercial name for a kind of prepared tobacco.

Shagreen. A species of leather, supposed formerly to have been prepared from the skin of the *shagree*, a species of whale. It is prepared from horse or ass skin, its granular appearance being produced by embedding in it, whilst soft, the seeds of a species of chenopodium, and afterwards shaving down the surface: it is dyed with the green produced by the action of sal ammoniac on copper filings. It was formerly much used for watch, spectacle, and instrument cases, and was made chiefly in Astracan.

Shah (Pers. *prince*). The title given by European writers to the monarch of Persia, who in his own country is designated by the compound appellation of PADISHAH.

Shah-namah (*The Book of Kings*). The most ancient and celebrated poem in the modern Persian language, by the poet who received as a title of honour the name 'Firdousi' (*of Paradise*), by which he is known. Its date is supposed to be about A.D. 1000. A complete translation into English, in four volumes, was published by Captain Macan, Calcutta 1829.

Shake (A.-Sax. sceacan). In Music, a quick alternate repetition of the note above with that over which the mark *tr* is placed, commonly ending with a turn from the note below.

Shakers. In Ecclesiastical History, a sect said to have originated by a secession from the body of Quakers, in 1747, in Lancashire; they received their nickname from the peculiar contortions of body which they adopted in their religious exercises. Anne Lee, the leader of this sect, joined the society in 1758; and considering herself persecuted in England, went with a few followers to New York in 1774. She died ten years afterwards, at which time her sect had made great progress in America.

Shako. The headdress worn by all infantry of the line in the British army, and by the Austrian and some other troops.

Shale (Ger. schale, *a shell*). A name given to certain argillaceous rocks, which split in some degree like slate, but much less perfectly, and are so little altered as to be easily reducible to clay by mechanical rubbing and pounding. Shales are very common in the coal measures, both in England and elsewhere, but they are not essential to the presence of coal. Some shales contain a marked proportion of bituminous matter capable of being separated by distillation at a low and regulated temperature. These are called bituminous shales, and, though generally distinct, they pass into coals in some places and cannot be distinguished from them. [BITUMINOUS SHALES.] Shales differ from schists in being almost entirely argillaceous and slightly metamorphic. Their impurities are iron and limestone, which occur as accidental and not as essential ingredients. They differ from slates in being less perfectly metamorphosed.

The shales in the coal measures are often loaded with fossil plants, which are very slightly changed. Slates, when they contain fossils, exhibit them in a greatly altered state, and schists contain only inorganic and crystalline minerals. Notwithstanding these broad distinctions, the young geologist may occasionally find difficulty in distinguishing shales from slates, and either of these rocks from schists. [SCHIST.]

Shallop (Fr. chaloupe). An open, broad boat, once employed by fishermen, but now nearly superseded by luggers and yawls. It has two masts rigged schooner-fashion.

Shallot or **Eschalot** (Fr. échalotte). The *Allium ascalonicum* of Linnæus. It possesses the flavour of garlic, but is less pungent, and is highly esteemed in cookery.

Shamanism or **Schamanism.** A general name applied to the idolatrous religions of a number of barbarous tribes, comprehending those of Finnish race—the Ostiaks, Samojeds, and other inhabitants of Siberia as far as the Pacific Ocean. These nations generally believe in a Supreme Being, but they assign the immediate government of the world to a number of secondary gods, both benevolent and malevolent towards man. The *shamans* or priests possess the power of propitiating such as are malignant. For accounts of these remote people, see Von Wrangel's *Journey to the Polar Sea*.

Shammy or **Shamoy.** The tanned or tawed skin of the chamois goat. Any soft pliable leather now passes under the name. [LEATHER.]

Shampooing. A name given to an operation which consists in pressing the joints and rubbing them, so as to mitigate pain, and restore tone and vigour to the parts.

Shamrock. The popular emblem of Ireland, corresponding to the rose of England, and the thistle of Scotland. It is generally believed to have been the plant called white clover, *Trifolium repens*; but others suppose it to have been the wood sorrel, *Oxalis Acetosella*.

Shank. In Architecture. [FEMUR.]

Shank of an Anchor. The shaft or principal member. It sustains the flukes at one end and the shackle at the other; it passes through the beam, if of wood, or is pierced by it if of iron.

Shank of a Hook. The straight part above the bent portion.

Shank Painter. The rope or chain which passing round the shank of the anchor, lying horizontally, confines it to the ship's bow, abaft the cathead.

Shark (Lat. carcharus, Gr. κάρχαρος). A large genus of fishes (*Squatus*). All these fishes have five branchial openings on each side of the neck, resembling two fissures.

Some are ovo-viviparous, whilst others lay eggs covered with a hard and horny case.

Sharp (A.-Sax. scearf, Ger. scharf). In Music, a character ♯, which prefixed to a note signifies that it is to be sung or played a semitone higher than it naturally would have been without such character.

Shaster. The Hindu name Shaster, or Sastra, denotes the book which contains the interpretations or explanation of the Vedas by *sasta*, i.e. science. Of such books we have the Vedanga-Schastra, the Schastra-Bade, and several others.

Shea Butter. A kind of solid oil, obtained in Africa from the seeds of the Shea-tree, *Bassia Parkii.*

Sheaf. In Mechanics, a solid cylindrical wheel fixed in a channel and movable about an axis, as in the block of a pulley. [SHEAVE.]

Shear Steel. A kind of steel made by welding several bars together, and again drawing them out. It is used for clothiers' *shears*, and many other cutting instruments. [STEEL.]

Shearing. The term in Scotland for reaping.

Shearing Sheep. The operation of clipping off the wool from the bodies of ewes and lambs; generally performed in the beginning of summer, when the animals are not likely to suffer from being deprived of their warm covering, and when there is sufficient time for the wool to grow again before winter.

Sheath (A.-Sax. sceath, Ger. scheide). In Botany, a term applied to a petiole when it embraces the branch from which it springs, as in grasses; or to a rudimentary leaf which wraps round the stem on which it grows, as in the scape of many Endogenous plants.

Sheathing. The covering laid on a ship's bottom to defend it from the worms. Sheets of thin copper nailed on with copper nails constitute, at present, the sheathing of all the better kinds of vessels. Lead has been used, at least as early as the time of Trajan; thin planking of fir was subsequently employed; and large-headed iron nails, called *scupper nails*, are used still for the same purpose on the bottoms of old hulks, piles, &c. Zinc and different compositions have been proposed as substitutes for copper, but they have proved less successful, as the copper produces by its oxidation a poisonous acid which deters sea-animals from adhering. The oxidation, however, gradually wastes the copper; and Sir H. Davy ingeniously suggested the application of pieces of zinc or iron upon different parts of the copper surface. These pieces of zinc or iron by the action of the sea-water render the copper electro-negative, and capable, therefore, of resisting the oxidising and corrosive agencies of the substances held in solution. The pieces so applied have been properly called *protectors*; but by occasioning the precipitation of earthy matters upon the copper, while they effectually *protect it*, they render its surface favourable to the adhesion of weeds, barnacles, &c., and sometimes to such an extent as to interfere with the passage of the ship through the water: and upon these grounds Sir Humphry's valuable suggestion has been neglected. When vessels are laid up in dock, the protectors are in successful use.

Sheave. The wheel in a pulley. In ships' blocks it is usually of brass or lignum vitæ, not unfrequently in combination, a square coak or bush of brass being inserted in the centre of a wheel of lignum vitæ. *Sheave-hole* is the hole through a block or spar in which a sheave is fixed.

Shechinah (Heb. shâkan, *to dwell*). The Jewish name for the Divine presence, which is represented as resting, in the shape of a cloud, over the 'propitiatory,' or 'mercy-seat,' as it is rendered in our translation (Lev. xvi. 2). The Jews reckon it among the five particulars which were present in the first temple, and wanting in the second. On this account God is so often said in Scripture to 'dwell between the cherubim;' i. e. between the images of cherubim on the mercy-seat. (1 Sam. iv. 4; Psalm lxxx. 1, &c. See, amongst other authorities, the special dissertations of Lowman and Skinner *On the Shechinah.*)

Sheep. [OVIS.]

Sheepshank. A very useful knot for shortening a rope in the middle, without cutting it or loosening its ends. It is of service in preventing two blocks coming together, or in shortening the backstays when a mast is struck. This knot (shown at fig. 5, art. KNOTS) is formed by doubling the rope in three parts, and taking a hitch over the bight at each end with the other rope.

Sheer (A.-Sax. scyr, Ger. schier). The curve which the line of ports, or of the deck, presents to the eye when viewing the side of the ship. When these lines are straight, or the extremities do not rise, as is most usual, the ship is said to have a straight *sheer.*

Sheer Battens. In Shipbuilding, long battens by which the position of the wales or bends is marked on the timbers preparatory to those planks being bolted on.

Sheer Plan. In Naval Architecture, the longitudinal section of a ship, taken through the keel, at right angles to the horizon. It shows the position of every point in the vessel in regard to its distance fore or aft of the midship point, and to its height above the keel.

Sheer Strake. In Shipbuilding, a thick strake of planking immediately under the gunwale.

Sheers. Apparatus for raising heavy weights to a considerable height, as hoisting masts into a ship, or boilers into a steam-vessel. The easiest-formed sheers are made of two spars lashed together near the top with a block suspended from the point of intersection. The resemblance borne by such spars to an open pair of shears is said to have suggested the name. In permanent sheers, employed in dockyards, the upper ends of the spars are cut off, the tops joined by an iron cap and bolts, the bases firmly set in masonry, and the appa-

ratus is lowered or raised by chains working to the top of a massive mast, rising vertically from between the feet of the spars. In some instances a pair of sheers is placed on each side of the centre spar, the whole being built on a stone causeway, between two basins.

A sheer hulk is an old hull fitted with sheers. It has the advantage of locomotion, but the weight of modern boilers and masts is so great as to have caused the sheer hulk to become nearly obsolete. Its place has in some degree been taken by the DERRICK.

SHEERS. In Artillery, two spars from thirty to forty feet long, lashed together at one end. Their other ends are planted in the ground, the lashed ends being raised by tackle, and fixed by guy ropes. To the lashed end is attached a tackle; and the whole arrangement is used for mounting and dismounting guns from towers, &c., in the same manner as a DERRICK.

Sheet (Span. escota). The rope attached to the after or leeward clew or corner of a sail, to extend it to the wind. In the square sails above the courses, the ropes attached to both clews are called *sheets*: in all other cases the weathermost one is called a *tack*.

Sheet Anchor. The largest and most powerful anchor carried by a ship.

Sheik (Arab. *elder* or *eldest*). A title of dignity properly belonging to the chiefs of the Arabian tribes or clans. The heads of monasteries are also in some instances termed sheiks among the Mohammedans. It is also the title of the higher order of religious persons who preach in the mosques. The mufti of Constantinople bears the title of Sheikh-ul-Islam.

Shekel. The name of a weight and coin in use among the Jews. The weight of the shekel was about half an ounce in English avoirdupois weight, the value of the coin being 2*s.* 7*d.* There were two standards of the shekel: the shekel of the *sanctuary*, which was used in calculating the offerings of the temple, and all sums connected with the sacred law; and the *royal* or *profane* shekel, used for all civil payments. Various opinions are entertained respecting the relative value of these two standards; but nothing certain can be averred on the subject. Wener and Michaelis (without, however, any sufficient reason, as it appears) are of opinion that the shekel used in commercial transactions differed from both of these. (Wener, *Biblisches Realwörterbuch*, art. 'Sekel.')

Sheldrake. The common name of the species of duck called *Anas tadorna*, which is the type of the subgenus *Tadorna* of Ray and modern ornithologists. This elegant species frequents many parts of our coast, and remains throughout the year. The female commonly selects a rabbit-hole in which to deposit her eggs, which are sometimes as many as sixteen in number. The sheldrake feeds on small fish, marine insects, and sea-weed.

Shelf (A.-Sax. scylf). On Shipboard, a longitudinal timber running around the inner side of the ribs, and bolted to them as well as to the stem and sternpost. The shelves impart great longitudinal strengthening to the ship, and at the same time serve to sustain the decks.

Shell (A.-Sax. scyl). The hardening principle of shell is generally carbonate of lime nearly pure. The animal principle, in the porcellaneous shells, is a small quantity of soluble gelatine; in the mother-of-pearl shells, it is albuminous. The latter, therefore, when steeped in dilute muriatic acid, leave a membranous or cartilaginous residue; but the former are entirely soluble. For the form, structure, and mode of growth of shell, see CONCHOLOGY.

SHELL. In Artillery, a hollow projectile. A *common shell* contains a charge of powder, which is ignited at the required time by means of a fuse, and so bursts the shell, the fragments being very destructive. The fuse of a common shell is generally so arranged as to burst the shell upon its striking the object. [MARTIN'S SHELL; SEGMENT SHELL; SHRAPNEL SHELL.]

Shell Lac. [LAC.]

Shell Marl. A deposit of clay and other substances, mixed with shells, which collects at the bottom of lakes.

Shelley's Case, The Rule in. In Law, an ancient doctrine of real property law, still of great practical importance. It may be shortly stated as follows: When a person by any gift or conveyance takes an estate of freehold, and in the same gift or conveyance an estate is limited to his heirs, the words *the heirs* are words of *limitation* of the estate of the ancestor, i. e. they are considered as defining the estate or interest taken by the ancestor, and not as giving any estate or interest to the heir individually. Thus, for instance, if an estate be given to A for life, and after his death to his heirs, A will take an absolute fee simple as if the gift had been simply to him and his heirs, and the person who may be the heir of A will take nothing unless by descent or gift from A.

Shepardite. A Mineralogical synonym of Schreibersite.

Shepherd Kings. Legendary kings of Egypt, sometimes called Hycsos. According to Bunsen (*Egypt's Place in Universal History*), the conquest of Egypt by Hycsos or Amalekite invaders took place 2547 B.C., and the dynasties then established held the native princes as their tributaries for about 900 years; the rise of the eighteenth dynasty in 1625 B.C. being accompanied by the expulsion or withdrawal of the Hycsos and the bondage of the Israelites. For the value of this chronology, see SESOSTRIS. (Sir G. C. Lewis, *Astronomy of the Ancients*, ch. vi.; *Edinburgh Review*, July 1862, p. 101.)

Sherbet (a word borrowed from the Persian). A favourite beverage in the East bearing some resemblance to our lemonade, made of water, lemon juice, and sugar, with the addition of

some other ingredients, such as rose water, to give it a delightful perfume.

Sheriff (originally shire-reeve, from the Saxon, meaning the reeve or governor of the shire). The title of that functionary who acted at first only as the deputy of the earl, hence styled in Lat. *vice-comes*, but who has long been the chief civil officer in each county, where he is styled bailiff of the crown, and where he is specially intrusted with the execution of the laws and the preservation of the peace. For this purpose he has at his disposal the whole civil force of the county—in old legal language, the *posse comitatus*. The most ordinary and important functions of the sheriff, which he universally exercises by a deputy, called under-sheriff, for whose conduct he is responsible, consist in the execution of writs issuing from the superior courts, or awarded by the judges on their consent, to take effect within the county. The sheriff himself only executes in person such parts of his office as are either purely honorary, such as attendance upon the judges on circuit (for whose lodging he is also bound to provide); or as are of some dignity and public importance, such as the presiding over elections and the holding of county meetings, which it is in his power to call at any time.

Sheriffs were originally chosen by the freeholders of the county, except in some few counties where the office was hereditary, as it was in Westmoreland, till the death in 1849 of the last earl of Thanet, without issue (see stat. 13 & 14 Vict. c. 30). The system of popular election was abolished in the reign of Richard II., and sheriffs have long been appointed by the crown upon presentation of the judges, in a manner partly regulated by law, partly by custom; but sheriffs may also be nominated by the crown without recommendation of the judges, and are then familiarly styled *pocket sheriffs*. The city of London has, by charter, the right of appointing sheriffs of London and Middlesex. Those appointed in either way are bound under a penalty of 500*l.* to serve the office, except in specified cases of exemption or disability. The description given of the office in England applies to Ireland without variation, except as to the time of its origin.

Sheriff Depute. In Scotland, the principal sheriff of a county. He is named by the crown, must be an advocate of three years' standing, and receives a salary. He is entitled to name sheriff substitutes; executes writs, returns juries, &c.; decides on claims for enrollment in the county lists of parliamentary voters, and exercises a certain criminal jurisdiction. He also holds civil courts for the recovery of small debts, and a court of record, the jurisdiction of which extends to all personal actions, and possessory actions for the recovery of real property.

Sherry. A Spanish wine made from the grapes of Xeres in Andalusia. Genuine sherry is a rich dry wine, containing from 20 to 23 per cent. of alcohol: there are many varieties, and it is extensively imitated and adulterated. [WINE.]

Shew-bread. In the Old Testament. The name given to the twelve loaves of bread, one for each of the twelve tribes of Israel, which were appointed to be placed every Sabbath 'on the pure table before the Lord,' for the sustenance of the priests. They appear to be the same with the 'shew-bread' in 1 Sam. xxi., where the act of David in taking these loaves for the nourishment of himself and his followers is related.

Shiah. A Mohammedan sect who consider Ali, the fourth caliph, as the rightful successor of Mohammed, and regard his three predecessors, Abubekr, Omar, and Othman, as usurpers. The Persians belong to this division—the Mohammedans who hold that Abubekr and his two next successors were legitimate caliphs being called Sonnites.

Shibboleth (Heb. *a flood*). The name given to a test by which the Jews sought to distinguish true persons or things from false. The following account is given of the origin of this term: After the battle gained by Jephtha over the Ephraimites (Judges xii.), the Gileadites commanded by the former secured all the passes of the river; and on an Ephraimite attempting to cross, they asked him if he was of Ephraim. If he said no, they bade him pronounce the word *Shibboleth*, which the Ephraimites, from inability to give the aspirate, called *Sibboleth*; and by this means he was detected, and instantly thrown into the river. In modern times this word has been adopted into the language of politics, in which it signifies those political opinions on which all the members of a party are agreed, or the watchword by which it is intended to unite them.

Shield (A.-Sax. scyld, Ger. schild). A piece of defensive armour, very extensively used before the invention of gunpowder, and still employed by many nations among which military art has made imperfect progress. The ancient Greek shield, as described in the Homeric poems, was large and massive, sufficient to cover the man from the face to the knee, composed of leather, inlaid in some instances with metal. That of the Roman legionary was four feet high and two and a half broad, formed of wood covered with leather, and strongly guarded with bosses of iron or bronze. The ancient Britons and other nations of antiquity wore round, light, basket-like shields, often of wickerwork; more resembling the parma or lighter shield of the Romans. The Norman shield, as used in England down to the time of Henry II., was 'of the form called kite or pear-shape,' flatter at first, afterwards approaching to the semi-cylindrical. Heraldic devices were first borne on it, so far as is distinctly ascertained, in the reign of Henry II. (*Pictorial Hist. of England*, i. 640.) In that of Edward IV. the shield had become triangular: the point of the triangle was rounded off about the end of the fourteenth century. Afterwards the shape of the shield, as worn by knights, became more

and more fantastic. In actual service it fell gradually into disuse, as sword and buckler fight, the favourite pastime as well as warlike practice of former days, became obsolete after the rapier and dagger had been introduced in the reign of Elizabeth. The Highlanders carried the target with the broad sword to a much later period. (Hewitt's *Ancient Armour and Weapons in Europe.*)

SHIELDS. In Botany, little coloured cups or lines with a hard disc surrounded by a rim, and containing the fructification of lichens.

Shilling (A.-Sax. scilling, Dan. skilling). An English silver coin equal to twelve pence, or the twentieth part of a pound sterling. Among the Anglo-Saxons, the value of the shilling was only five pence; it afterwards underwent many alterations, containing sometimes sixteen pence, and often twenty pence. The period when it obtained its present value is assigned to the reign of Edward I. Many other countries besides England have a coin of this name; of these, perhaps, the Hamburg schilling is the best known. Its value is 1*d.* English.

Shiloh (Heb.). A name mentioned in the prophecy of Jacob, Genesis xlix. 10, and by some interpreters supposed to designate the Messiah; but the real meaning of the passage seems to be still a subject of controversy.

Shingle (Ger. schindel, from schinden; Lat. scindo, *to cleave*). The coarse gravel, or accumulation of small stones, found on the shores of rivers or the sea; in the latter case the term *sea-beach* is applied.

Shingles (a corruption of the French word *ceingle*, from the Lat. cingulum, *a belt*). This eruptive disorder (known to nosologists by the title of *Herpes zoster*) is generally ushered in with febrile symptoms, followed by an itching or tingling sensation of some part of the body, occasioned by patches of little red pimples, forming in the course of twenty-four hours small transparent vesicles; these succeed each other till they at length form a kind of belt round some part of the trunk or abdomen: they often form small ulcerations and scabs, continuing their progress for three or four weeks. This disorder is not contagious, and generally very slight; but in irritable habits the itching occasions want of rest and fever, and it is sometimes attended by a deep-seated pain of the affected part. The cause of shingles is generally obscure, though it may sometimes be referred to indigestion and suppressed perspiration: young persons are most subject to it. Gentle aperients and diaphoretics, strict attention to the diet, and occasional anodynes, are the only internal remedies generally required; and externally a little cold cream or fresh spermaceti ointment, or the occasional application of a very weak Goulard's lotion, is all that is necessary. [HERPES.]

SHINGLES. In Architecture, small slabs of wood, or quartered oaken boards, used instead of slates or tiles for covering churches or spires. They are sawn to a certain scantling, or rather cleft to about an inch thick at one end, and shaped like wedges, four or five inches broad and eight or nine inches long.

Ship (Ger. schiff, Gr. σκάφος, *a skiff*, from σκάπτω; Ger. schaffen; hence Eng. skipper). A general term for all large vessels, formerly restricted to such as had three complete masts; i.e. lower, top, top-gallant, and royal masts; but in modern days, when the application of steam and innumerable experiments in rigging have upset any universal principle of rig, the only limitation of the term *ship* is practically by the size of the vessel. The ship, as a whole, may be treated conveniently under four great heads; the hull, the masts and rigging, the crew, the cargo. As regards the hull, the principles for designing its shape are shown under NAVAL ARCHITECTURE; the execution of the details are described in SHIPBUILDING; the sailing gear will be found under MASTS and RIGGING. The general functions of the *personnel* are stated under their respective titles, while under various minor headings the minutiæ of a ship's equipment are fully particularised. It remains in the present article to afford some insight into the internal arrangements of the vessel.

After the hull has been completed, the ballast, which is necessary in most ships to keep them upright when under sail, is spread over the bottom of the hold, chiefly amidships, on each side of the ship's centre of gravity. In ships of war and yachts, pigs of iron compose the ballast; in merchant vessels any insufficiency in the cargo for the same purpose is met by filling with gravel or some local substitute, which can be discharged as more cargo is shipped. On the ballast are laid loose pieces of wood, called *dunnage*, on which rest the iron tanks, or casks, containing the water to drink. The hold in large ships is divided by partitions into the fore, main, and after holds. At the fore extremity, in men-of-war, are the gunner's, boatswain's, and carpenter's store rooms, containing arms, supplies of rope, bolts, pump gear, and other materials of the fittings, or for repairs. In this part also is the fore powder magazine, when there are two. In the fore hold are stowed water, wood for firing, and, separated by a strong partition, coals. In the main hold are stowed water, stores, chain cables, &c. In the after hold are the provisions; and in the *spirit room*, the spirits: here also is the powder magazine. In the narrow and shallow after extremity is stowed the bread or biscuit. The spare sails are kept in a space called the *sail room*, over the fore hold. The hemp cables are kept in the cable tiers, on a deck over the main hold. These decks immediately over the holds constitute the fore and after *cock pits*. In large ships, the whole deck is called the *orlop* deck. On the *lower* deck, which is next above the former, the men mess and sleep. In frigates and smaller vessels, this deck is the next below the upper deck; in two-deckers the main deck intervenes; in

three-deckers the main and middle decks. All these decks from the lower deck upwards are gun-decks. The above description applies to sailing vessels only; in steamers the presence of the engine room, the screw-alley, the large bunkers for coal, and other requirements, involve great and varying alterations in the internal arrangements.

In merchant ships the arrangements depend, of course, on the size of the vessel and the nature of the cargo. In all these vessels, however, the place allotted to the crew is in the fore part, and is called the *fore peak*.

Ship, Armed. In the English usages of war, a private vessel occasionally taken into the service of government in time of war, armed and equipped like a regular ship of war, and commanded by an officer of the navy.

Ship of the Line. Formerly one of the line of battle; i.e. a ship of two or more gun-decks. It is difficult to say what class of vessels in modern warfare would represent ships of the line; it is highly improbable that a battle will ever again be fought in the line order; and the French iron-sided vessels, the Magenta and Solferino, are the only specimens in existence of armoured ships of two gun-decks. The line-of-battle ship may be considered to exist only until the few remaining old ships shall be worn out.

Ship Money. The celebrated tax imposed by Charles I. without authority of parliament, which proved one of the proximate causes of the discontents that ended in the great rebellion. This device was first put in practice in 1634. It was by a writ, directed to the sheriff of every county, to provide a ship for the king's service; accompanied by written instructions, appointing a sum of money to be levied instead. This writ was framed by Attorney-General Noy. The tax was paid for about four years without opposition; when the question of its legality was raised by the refusal of Hampden to pay his share. It was argued before the judges in the Exchequer Chamber, of whom a great majority gave judgment for the crown. The Act 'whereby all the proceedings in the business of ship money were adjudged void, and disannulled, and the judgments, enrollments, and entries thereupon vacated and cancelled,' was one of the first proceedings of the Long Parliament.

It appears that, in the early ages of English history, the maritime, and perhaps some of the inland, counties were taxed specially for the supply of the king's navy, or as it was technically called *warda maris*. This regulation was only part of the general obligation laid on all tenants, however quit they were of other services, to defend the realm in case of invasion; and it might perhaps have been contested that the demand of an aid for such an emergency was exceptional, and not comprised within the rule of the great charter. But the revival of the tax at Noy's instance was a very different affair. It was levied on all counties alike, it was neither intended for, nor devoted to, the maintenance of a navy, and it was thoroughly understood to be a device for taxing the nation without its consent, in the interest of the court, and with a view to coercing the national liberties.

Ship Pendulum. A pendulum used in the navy to ascertain the *heel* of a vessel, so that allowance may be made, in laying a gun, for the inclination of the deck.

Ships, Registry of. In Commercial Navigation, the registration or enrollment of ships at the custom-house, so as to entitle them to be classed among, and to enjoy the privileges of, British-built ships.

The registry of ships appears to have been first introduced into this country by the Navigation Act (12 Ch. II. c. 18, A.D. 1660), and was provided for by a series of subsequent statutory regulations, now embodied in the Merchant Shipping Act 1854 and amending Acts.

The great and perhaps the only original object of the registration of ships, was to facilitate the exclusion of foreign ships from those departments in which they were prohibited from engaging by the navigation laws, by affording a ready means of distinguishing such as were really British. It has also been considered advantageous to individuals, by preventing the fraudulent assignment of property in ships; but Lord Tenterden has observed, in reference to this supposed advantage, that 'the instances in which fair and honest transactions are rendered unavailable, through a negligent want of compliance with the forms directed by these and other statutes requiring a public register of conveyances, made the expediency of all such regulations, considered with reference to private benefit only, a matter of question and controversy.' (*Law of Shipping*, part i. c. ii.)

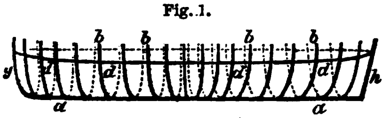
Shipbuilding. The application, in practice, of the theoretical design developed by the naval architect. The principles which should regulate the choice of a ship's form and dimensions are laid down in the article NAVAL ARCHITECTURE. The shipwright has three detailed plans delivered to him—the sheer plan, the half-breadth plan, and the body plan. From these plans he has to work, and to produce a structure corresponding exactly in shape, size, and strength, to that delineated by the naval architect. Whatever the material of which the ship is to be constructed, the external form will be the same, though the internal strengthening differs in each case. Building in wood is conducted in quite a different manner from building in iron, and therefore it will be necessary to consider them separately. Wooden vessels are built for all purposes; ships of thin iron-plate for the ordinary carriage of passengers and freight; while armour-plated vessels are almost invulnerable ships intended for warfare with heavy modern artillery. These three constructions need separate description. As the oldest, as yet the

commonest, and the most complicated, the wooden ship shall first be dealt with.

A ship may be described as a hollow box, in shape approaching an elongated rectangle; though for reasons of speed the solid angles are reduced to curved surfaces. It is made to bear heavy burdens, so heavy that if water were to come in in any large quantity the structure would sink. Yet it is at the mercy of an element of gigantic power and fearful violence. Immense strength and solidarity are therefore requisite to keep the water out. Could the form be circular, or even square, this might be comparatively easy, but speed is an essential concurrently with carrying power. Every effort towards locomotion tends to produce disruption in the structure. The length must many times exceed the breadth; fracture sideways becomes imminent. The length involves frequent suspension on two waves, or balancing on one; *separation lengthwise* is to be dreaded. Is motion sought from the wind? A vast spread of canvas, acted on by the storm, tends to submerge the prow, which the hull's buoyancy counteracts by pressure in another, but not an opposite, direction. Under this conflict of force every timber strains. Is steam the motive power? Motion is obtained by rapid and strong blows upon the water. Every blow makes the whole ship vibrate, and loosens that caulking by which alone the timbers can be watertight. These difficulties will show that the shipbuilder has *by skill to* render vastly strong a form in which weakness is a necessary constituent. A long narrow box is obviously a weak form. It is only by much internal bracing that it can be rendered strong; and this internal bracing must be so contrived that it shall interfere as little as possible with the stowage room and the facility of communication inboard.

Figs. 1 and 2 are intended to show in an elementary manner the combination by which

Fig. 1.



strength is secured. The *keel a* is a massive beam, forming as it were the backbone of the ship. Across it are laid the flat and lower ends of the ribs or timbers *b*, which support the sides. On the floor formed by these cross-pieces is laid the *keelson c*, an inner beam similar to the keel. The keelson is firmly bolted through the cross-pieces to the keel, thus holding the ribs at their bases the relative distances apart. Within the ship, on the inside of the ribs, a strong timber (*d*) called the *shelf* is bolted from stem to stern. This retains the ribs in a parallel position, and at the same time supports the *deck e*. The deck, being slightly arched to prevent it from sinking in the middle under heavy burdens, has a tendency to force the vessel's sides outwards. This is prevented by the employment of knees, *f*, which are brackets—now most commonly of iron, but formerly of wood grown for the purpose. These knees hold the ribs to the cross-beam on which the deck rests. The beam thus has double functions. Through the knees it holds the sides together; and by its rigidity it prevents the ship being crushed inwards by the violence of the waves. From the respective ends of the keel rise the *stem g* and *stern-post h*. At these points the ship's *beam* or width is the thickness of the post only. The pairs of ribs gradually become wider in their compass, till the widest part of the ship is reached. The ribs or timbers near the stem and stern are set at angles less than right angles to the keel, as shown in fig. 3, in which the spectator is supposed to look down from above. The parts of the vessel in which these ribs are thus obliquely set constitute the *cant bodies*. The ribs being bolted at the proper distance or *room and space* apart, the intervening space is occupied by *fillings in*, i.e. by timbers, somewhat less thick, jammed tightly between to a point above the watermark. This gives solidity to the structure. After the filling in, the *planking* is bolted on to the ribs within and without, being *rabbeted* into the keel below and into the stem and stern-post at the ends. It may now be useful to survey the elements of strength which have been arrived at. The keel, keelson, shelves, and planking, bind stem to stern, and give strength in the direction of the length. At bottom, the bolts through keel and keelson, and, higher up, the knees acting on the beams, maintain the width. There remains weakness in the direction of the depth, for each rib of necessity consists of several pieces, joined one above the other. The planking does not offer much resistance to a longitudinal separation. Strength in this particular is obtained by *diagonal trussing* within, either in wood or, preferably, iron-plate. It consists of bands bolted each to several ribs at an angle of about 45°.

Fig. 2.

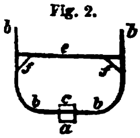
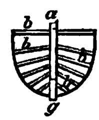


Fig. 3.



Having thus described in general terms the system on which a wooden vessel is constructed, it is unnecessary in the present article to enter into a minute description of the component parts, as each will be found described under its name. It is proper, however, to observe that in all parallel work, as the floors, the planking, &c., care is taken so to distribute the joints that they shall be a minimum cause of weakness. The greater timbers, as the keel, keelson, and ribs, cannot be obtained in one length. Their parts are then joined by scarfs, coaks, dowels, or chocks.

Iron Shipbuilding.—Although the relative durability of wood and iron as materials for shipbuilding is still a disputed point, and must so remain for many future years, it has been settled definitely that, while in actual use, iron possesses many advantages over wood; size for

size, the iron ship is far lighter; weight for weight, she has greater strength. From the ease with which wrought iron can be rolled into any shape, the curves of the vessel's form are obtained without the cumbrous complications of timber necessary in wooden building.

Following the former simile of the oblong box, the iron vessel may be looked upon as a tubular girder closed at both ends. The nomenclature of the parts is the same as in the wooden ship; but there, except in outward form, the resemblance ends. The structure is, or should be, mutually supporting throughout; the keel therefore ceases to be of the same vital consequence as in wood, and is retained rather in aid of sailing qualities than to give strength. It is usually composed of boiler-plates strongly riveted together. Rising from it, and riveted to it on either side, are the ribs, which are usually *made* girders. These are covered (to represent the planking) with large sheets of boiler-plate, riveted together at the edges, of a thickness varying from $\frac{5}{16}$ to $\frac{15}{16}$ of an inch. In large and fine ships, an inner skin of iron is laid within the girder-ribs. Where this arrangement is adopted, there is a series of air-compartments (separated from each other by the ribs) all round the vessel, which aid flotation in the ordinary way, and in the event of accident offer the obstacle of a second skin to the entrance of water. The ribs are held together and apart by beams of I iron. Over these, thin iron plates are fastened, and above these plates wooden planks, which form the several decks. It is becoming a recognised datum that in an iron ship the strength of the deck is as important as that of the bottom; the deck being the upper, as the bottom is the lower, transverse strength of the girder formed by the whole ship. An additional security is afforded by *watertight bulkheads*, which are diaphragms of iron stretched across the ship at intervals from deck to keel, and provided with watertight doors of communication. The bulkheads divide the vessel into completely separate compartments, a few of which suffice to float it, when from any mishap the others become filled with water. Many vessels have owed their safety during ocean voyages to their watertight compartments. The greatest drawback in the case of iron vessels is the rapidity with which the bottom fouls from the adhesion of marine animals and plants. The fouling speedily destroys speed. Many compositions for coating the bottom to prevent fouling have been tried, but without permanent success. Vitreous plates have answered well. In the best modern vessels the following plan has been adopted: thin wooden planking is bolted by iron screws to the ship's bottom; on this another coat of planking is fastened by copper screws, care being taken that the iron and copper do not communicate. Outside the second line of planking the ordinary copper sheathing is made fast. By this process galvanic action between the copper and iron is precluded. There are numerous details in iron shipbuilding, as the arrangement of the girders, the beams, ties, &c., which vary continually, according to the principles or fancy of the naval architect, the purpose of the vessel, and the strength requisite for the seas which she is to navigate.

Ships of Iron and Wood.—Among modern shipbuilders iron has been frequently introduced in the internal arrangements of wooden hulls, as in the tie-beams, the inner planking, &c. Its use is advantageous, from the saving of space and weight effected without diminution of strength. Several builders have also affected a great saving in these respects by using iron girders for the ribs and covering them without with wooden planking.

Armour-plated Vessels.—Under the article Iron Armour Plate, a brief sketch has been given of the gradual introduction of iron armour as a defence in ships of war against the ponderous artillery of the present day. The conditions of strength as regards the armour have been detailed in that article: it is only necessary now to advert to the several builds which have been adopted or, perhaps more correctly, tried. It must, however, be premised that the ship and her armour are quite distinct: the armour being merely a defensive wrapper hung on, and contributing not in the least to the strength of the vessel as a sea-boat. The earliest specimens, of which the French 'Gloire' and British 'Warrior' are types, were simply large frigates of the most massive construction, clad in armour at the sides, the armour consisting of 4½ inches of iron on 18 inches of oak or teak. Many such vessels have been built; the hulls of some being of wood, those of others of iron. On a balance of advantages the preference is given to iron. The armour usually covers only the part of the broadside where the guns are, the bow and stern being without armour, except for a depth of perhaps four feet above and below the waterline. Watertight bulkheads are provided to secure safety if the bow or stern be pierced. When the ship is to act as a ram, an additional spur is often riveted over the edge and point of the ordinary stem to form a more powerful beak. After a charge this beak may be carried away, but the ship's stem ought to remain intact.

But the best armour, if struck very often by heavy steel projectiles, will be destroyed. The larger the surface which a ship presents to the enemy, the greater is her chance of destruction; it therefore occurred early to competitive inventors—among the foremost of whom were Timby and Ericsson, of the United States, and Captain Cowper Coles, of the British navy—to reduce the hull of the vessel to a mere platform, scarcely above the level of the water, and to carry the guns in a tower or towers. The Confederate Americans produced the Merrimac and Tennessee, two rams of this class, containing their armament in a raised fort, with sloping sides, which stood in the midst of

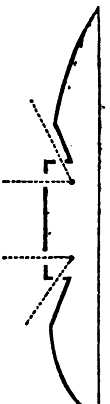
the deck; this fort was a fixture. The Federal Americans opposed it by a class of vessels, called 'Monitors,' from the name of the first so built, which mounted one or two enormous guns in a *revolving* turret, wholly above the deck. These offered a small mark to the hostile artillery; the turret was turned with ease by the steam engine, which also provided ventilation. The guns could be turned out of fire while loading, and could range in any direction when loaded. On the whole, they were considered a great improvement, and admirably adapted for river or harbour defence; but they were bad sea-boats, and the original Monitor went down head-first in a gale. It is fair, however, to say that in June 1866, the Miantonomoh, an American Monitor of improved build and heavy armament, crossed the Atlantic without difficulty, the Monadnock having previously successfully weathered the Horn.

Concurrently with the rise of the Monitors, Captain Coles has urged upon the British government the adoption of *turret ships*, which, like the Monitors, have revolving turrets, sunk, however, below the deck, with the exception of just sufficient height for the discharge of the guns. They differ from the American model in being sea-going masted vessels. The Royal Sovereign was altered from a wooden line-of-battle ship to a turret ship; but her former build prevented the full adoption of Captain Coles' principles. Her sides are plated with five-and-a-half inch iron, her deck with a less thickness. The turrets, of which she has four, are of five-inch iron, increased to ten inches near the embrasures; at all points there is a thick wood backing to the iron. Notwithstanding her defects, the Royal Sovereign has been pronounced admirably seaworthy, and her commanding officer has declared that, taken all for all, she is the most formidable vessel afloat. In June 1866, one of her turrets was experimented on with heavy shot at short range. At the close of the trial it was found to revolve with the same ease as at the beginning. A fundamental difference between the American and the British turrets, besides their respective heights above the deck, is that the former revolves, by the aid of the engine, on a central pivot based on the keel, while the latter is easily moved by a hand-winch on rollers under its periphery. It is impossible to doubt the superiority of the British plan, as regards both handiness and distribution of weight. The question of the comparative advantage of broadside and turret armoured vessels has been debated with vigour and acrimony for five years, and numerous scientific committees have reported on the subject. The general conclusion appears to be, that the turret vessel has the advantage for all purposes except fast cruisers, which require for various reasons sides and decks of the ordinary height. The advantages claimed for the turret are:—

1. That it is the best mode of carrying very heavy guns: (*a*) because their weight acts at less leverage and less destructively to the ship; (*b*) because there is a steadier platform from which to fire.
2. That it gives the best range: (*a*) because it is higher above the water than in a broadside; (*b*) because the direction in which it can be trained is only limited by the obstructions on the deck.
3. That the gunners and gun are safer: because during loading the port can in most cases be turned out of fire.
4. That it allows of greater rapidity of fire: because the gun can be kept always directed to the mark aimed at.
5. That it throws greater weight of metal on one side than is otherwise possible.
6. That it gives advantage of position, inasmuch as the turret vessel can keep her head in any direction most convenient.
7. That it allows of correct aiming concurrently with narrow portholes.

As the best specimens in the British navy of these rival classes, may be mentioned, for broadside ironclads, the Bellerophon, which has a powerful broadside; the Pallas, which has guns capable of being trained fore and aft, as well as to the broadside, her side being constructed, as in the annexed diagram, on the level of the portholes; and the Minotaur, a stupendous five-masted frigate, ironclad throughout. For turret vessels, the Royal Sovereign is a fine ship, but of wood; the Wyvern and Scorpion are smaller vessels, of iron, and very efficient; the Waterwitch, of 800 tons, is intended as a sort of turret gunboat, propelled by the ejection of water.

Fig. 4.



Approximate half-breadth plan of Pallas on the level of the portholes.

In foreign navies, the same models as in the British navy have been more or less followed, the American chiefly trusting to Monitors, the French to broadside ships, and among them having two two-deckers, the only specimens (and those not encouraging) of such ships among ironclads.

Shire (from A.-Sax. scyran, *to divide*; whence the verb *to sheer*). A territorial division. In modern language, *shire* is synonymous with *county*; but some smaller districts in the north of England retain the provincial appellation of shires: as Richmondshire, in the North Riding of Yorkshire; Hallamshire, or the manor of Hallam, in the West Riding, which is nearly coextensive with the parish of Sheffield. [COUNTY.]

Shire Clerk. An officer appointed by the sheriff to assist in keeping the county court.

Shire Mote. In Ancient English Law, the *shire meeting*, i.e. sheriff's court.

Shirt of Need. In the ages of chivalry, a garment, called by the Germans *nothhemd*, which was supposed to render the wearer proof against all wounds.

Shiva. [SIVA.]

Shoddy. A kind of woollen cloth, made from an inferior species of material, such as old stockings, flannel, and other soft goods. Its origin dates back as far as 1813, but it was long regarded as a dishonest production. The old goods are torn up into their original fibres by cylindrical machines armed with teeth, and reworked up. The price of ordinary shoddy varies from ¾*d.* to 5*d.* per lb., and the white from 2*d.* to 10*d.* Some goods, such as pea-jackets and low-coloured blankets, are made with only one part of pure wool to six parts of shoddy. [MUNGO.]

Shoe (Ger. schuh). A covering for the foot, usually made of leather. Among the Jews these coverings were made not only of leather, but of linen, wood, and, for soldiers, sometimes of brass and iron. The Roman shoe, or *calceus*, covered the whole foot, and was tied above with strings, being thus distinguished from the sandal or *solea*. The fashion of long points is the most singular feature in the history of mediæval shoes. These long-pointed shoes were called *crackowes*, and were tied by chains to the knee. An Act of Parliament in 1463 forbade the use and manufacture of such shoes; but the prohibition was ineffectual, and recourse was had to the excommunication of those who wore shoes with points exceeding two inches in length.

Shoemakers' Black. *Atramentum sutorium.* A name given by Pliny to sulphate of iron, or green vitriol, from the circumstance of its being used to rub over tanned leather, to which it communicates a black dye.

Shooting Stars. The article METEORS, LUMINOUS, contains a general résumé of our present knowledge of the phenomena among which shooting stars are included. In this place, therefore, we need only deal somewhat with the early history, and some of the more interesting details.

The apparent magnitudes of shooting stars are widely different. The greater part of them may be classed of the 3rd, 4th, 5th, and 6th magnitudes; but some occur which surpass stars of the 1st magnitude, and even exceed Jupiter and Venus in brilliancy. In some of them the globular form can be easily recognised; and, in fact, it is impossible, from their appearances, to make any distinction between the larger shooting stars and the smaller individuals of the class of meteors to which the name of FIRE-BALLS or *bolides* is usually appropriated.

Some of the shooting stars leave a luminous train behind them, which marks their path through the sky with a milk-white light. These trains for the most part disappear in a few seconds; but sometimes they continue longer, and even for several minutes. In the case of actual fire-balls, Dr. Olbers observed trains which continued from six to seven minutes; and Brandes, in one instance, estimated that fifteen minutes elapsed between the extinction of the fire-ball and the disappearance of the luminous train. The trains in general assume the form of a cylinder, the interior of which is void of luminous matter; and not unfrequently, before their disappearance, they take a curved form. The most probable explanation was held to be, that they were caused by finely divided solid and phosphorescent matter left behind by the meteor, and bent by currents of air. This explanation of the latter phenomenon has been placed almost beyond all doubt by the observations of M. Coulvier Gravier.

The older philosophers had formed various theories to explain these remarkable phenomena. By some they were supposed to be the products of an oily sulphurous vapour existing in the atmosphere, which being disposed in thin layers, and becoming inflamed by some means, would exhibit the appearance of a clear brilliant spark passing rapidly from one point to another. About the middle of the last century, when the effects and phenomena of electricity began to be better understood, Beccaria and Vassali, among others, regarded the shooting stars as merely electrical sparks; an hypothesis which was soon shown to be untenable. At a later period, when the inflammable nature of the gases became known, Lavoisier, Volta, Herbert, Toaldo, Gren, and others, referred these meteors to hydrogen gas, which, by reason of its inferior density, they supposed must be accumulated in the higher regions of the atmosphere. Dalton, however, showed that such accumulation cannot take place, inasmuch as all the gases which constitute the atmosphere must be equally diffused through its whole extent, according to the law of Mariotte. Deluc maintained that certain phosphoric exhalations generated in the earth, and becoming inflamed in the sky, formed the true essence of the shooting stars.

In this state the subject remained when Chladni published his celebrated work on the causes of the masses of iron and other similar substances found in Siberia by Pallas, in which he clearly established, by comparing the circumstances of a great multitude of observations, that fire-balls are meteors having their origin beyond our atmosphere; that, in fact, they are masses of nebulous matter moving in space with planetary velocities, which, when they come in the way of the earth in its revolution about the sun, and enter the atmosphere, are inflamed by its resistance and friction, and become luminous, sometimes scattering masses of stone and iron on the ground. Halley, Wallis, Pringle, Maskelyne, and others, had previously assigned a cosmical origin to these meteors, but without suspecting that masses of stone and iron fell from them. The close resemblance which the greater part of the shooting stars present to fire-balls, at once induced Chladni to consider these phenomena also as cosmical; that is to say, as small masses

of matter not having their origin in our atmosphere, but entering it from without, and which are either entirely consumed in it, or become extinguished when they have passed beyond it.

These conclusions, however, required to be confirmed by a more accurate investigation of the phenomena; for as yet no exact determination had been made of the actual average heights of the shooting stars above the earth, or of their orbits, velocities, or magnitudes. In the year 1798 this important but difficult enquiry was undertaken by Professors Brandes of Leipsig, and Benzenberg of Düsseldorf (both at that time students in Göttingen). Having selected a base line (about nine miles in length), they placed themselves at its extremities on appointed nights, and observed all the shooting stars which appeared, tracing their courses through the heavens on a celestial map, and noting the instants of their appearances and extinctions by chronometers previously compared. The differences of the paths traced on the maps afforded data for the determination of the parallaxes, and consequently the heights and the lengths of the orbits. On six evenings, between September and November, the whole number of shooting stars seen by both observers was 402; of these 22 were identified as having been observed by each in such a manner that the altitude of the meteor above the ground at the instant of extinction could be computed. The least of the altitudes was about 6 English miles. Of the whole there were 7 under 45 miles; 9 between 45 and 90; 6 above 90; and the highest was above 140 miles. There were only two observed so completely as to afford data for determining the velocity. The first gave 25 miles, and the second from 17 to 21 miles in a second. The most remarkable result was, that one of them certainly was observed not to *fall*, but to move in a direction away from the earth.

By these observations a precise idea was first obtained of the altitudes, distances, and velocities of these singular meteors. A similar but more extended plan of observation was organised by Brandes, in 1823, and carried into effect at Breslau and the neighbouring towns, by a considerable number of persons observing at the same time on concerted nights. Between April and October about 1,800 shooting stars were noted at the different places; out of which number 62 were found which had been observed simultaneously at more than one station in such a manner that their respective altitudes could be determined, and 36 others of which the observations furnished data for estimating the entire orbits. Of these 98, the heights (at the time of extinction) of 4 were computed to be under 15 English miles; of 15 between 15 and 30 miles; of 22 between 30 and 45; of 33 between 45 and 70; of 13 between 70 and 90; and of 11 above 90 miles. Of these last two had an altitude of about 140 miles, one of 220 miles, one of 280, and there was one of which the height was estimated to exceed 460 miles.

Of the 36 computed orbits, in 26 instances the motion was downwards, in one case horizontal, and in the remaining 9 more or less upwards. The velocities were between 18 and 36 miles in a second. The trajectories were frequently not straight lines, but curved sometimes in the horizontal and sometimes in the vertical direction, and sometimes they were of a serpentine form. The predominating direction of the motion of the meteors from north-east to south-west, contrary to that of the earth in its orbit, was very remarkable, and is important in reference to the theory of their physical origin.

A similar set of observations was made in Belgium in 1824, under the direction of M. Quetelet, the results of which are published in the *Annuaire de Bruxelles* for 1837. M. Quetelet was chiefly solicitous to determine the velocity of the meteors. He obtained six corresponding observations from which this element could be deduced, and the results varied from ten to twenty-five English miles in a second. The mean of the six results gave a velocity of nearly seventeen miles per second, a little less than that of the earth in its orbit.

Another set of corresponding observations was made in Switzerland on August 10, 1838; a circumstantial account of which is given by M. Wartmann in Quetelet's *Correspondance Mathématique* for July 1839. M. Wartmann and five other observers, provided with celestial charts, stationed themselves at the observatory of Geneva; and the corresponding observations were made at Planchettes, a village about sixty miles to the north-east of that city. In the space of seven and a half hours, the number of meteors noted by the six observers at Geneva was 381; and during five and a half hours, the number observed at Planchettes by two observers was 104. All the circumstances of the phenomena—the place of the apparition and disappearance of each meteor, the time during which it continued visible, its brightness relatively to the fixed stars, whether accompanied with a train, &c.—were carefully noted, and the trajectories projected on a large planisphere. The extent of the trajectories described by the meteors was very different, varying from 8° to 70° of angular space. The velocities appeared also to differ considerably; but the average velocity was supposed by M. Wartmann to be 25° per second. It was found, from the comparison of the simultaneous observations, that the average height above the ground was about 550 miles; and hence the relative velocity was computed to be about 240 miles in a second. But as the greater number moved in a direction opposite to that of the earth in its orbit, the relative velocity must be diminished by the earth's velocity (about 19 miles in a second). This still leaves upwards of 220 miles per second for the absolute velocity of the meteor, which is more than eleven times the orbital velocity of the earth, seven and a half times that of the planet Mercury, and probably greater than that of the comets at their perihelia.

Such are the principal facts which were early established respecting the heights, velocities, and orbits of the shooting stars; and it is from these, and others lately made which confirm them, that we have been enabled to form any probable conjectures respecting their origin.

The early theories, as already stated, ascribed an atmospheric origin both to shooting stars and fire-balls; but, although there is little doubt that shooting stars do not become visible until they are immersed in our atmosphere, yet the supposition of the atmospheric origin of these meteors is on other grounds altogether untenable.

Another hypothesis respecting their origin was, that they are bodies projected to our earth from volcanoes in the moon. Dr. Olbers was the first, perhaps, who showed the possibility of this hypothesis. On computing the forces necessary to overcome the moon's attraction, he found that a body projected from the moon with a velocity of about 8,500 feet in a second would not fall back on the lunar surface, but recede from it indefinitely; and that in order to reach the earth it is only necessary that the projectile should have the velocity of 8,300 feet, which is quite conceivable, being only about four or five times that of a cannon-ball. The hypothesis of the lunar origin of meteoric stones was adopted by Laplace, Berzelius, Benzenberg, and others; but the observed velocities of the shooting stars have rendered this origin extremely improbable with respect to them. In order to enter our atmosphere with a velocity of 20 miles in a second, it may be shown that if they come from the moon they must have been projected from the lunar surface with a velocity of about 120,000 feet in a second, which may be regarded as altogether impossible.

It thus appears that those shooting stars and fire-balls which have the planetary velocity of from 20 to 40 miles in a second, cannot with any probability be regarded as having their origin in the moon. Whether any individual bodies moving with a smaller velocity may have a lunar origin, is a question which cannot be decisively answered. 'To me,' says Dr. Olbers, 'it does not appear at all probable; and I regard the moon, in its present circumstances, as an extremely peaceable neighbour, which, from its want of water and atmosphere, is no longer capable of any strong explosions.'

Another hypothesis, suggested by Chladni, has now for some time met with gradually increasing favour. It consists in supposing that, independently of the great planets, there exist in the planetary regions myriads of small bodies which circulate about the sun, generally in groups of zones; and that some of these zones intersect the ecliptic, and are consequently encountered by the earth in its annual revolution.

Speaking of this hypothesis, which is now accepted on all hands, Mr. Joule says: 'Its likelihood will be rendered evident if we suppose a meteoric stone, of the size of a six-inch cube, to enter our atmosphere at the rate of eighteen miles per second of time, the atmosphere being $\frac{1}{160}$ of its density at the earth's surface. The resistance offered to the motion of the stone will, in this case, be at least 51,600 lbs.; and if the stone traverse twenty miles with this amount of resistance, sufficient heat will thereby be developed to give 1° Fahrenheit to 6,967,980 lbs. of water. Of course by far the largest portion of this heat will be given to the displaced air, every particle of which will sustain the shock, whilst only the surface of the stone will be in violent collision with the atmosphere. Hence the stone may be considered as placed in a blast of intensely heated air, the heat being communicated from the surface to the centre by conduction. Only a small portion of the heat evolved will therefore be received by the stone; but if we estimate it at only $\frac{1}{100}$, it will still be equal to 1° Fahrenheit per 69,679 lbs. of water, a quantity quite equal to the melting and dissipation of any materials of which it may be composed.

The dissolution of the stone will also be accelerated in most cases by its breaking into pieces, in consequence of the unequal resistance experienced by different parts of its surface, especially after its cohesion has been partially overcome by heat.

It appears that the varied phenomena of meteoric stones and shooting stars may all be explained in the above manner; and that the different velocities of the meteorolites, varying from four to forty miles per second, according to the direction of their motions with respect to the earth, along with their various sizes, will suffice to show why some of these bodies are destroyed the instant they arrive in our atmosphere, and why others, with diminished velocity, arrive at the earth's surface.

The presumptions in favour of the cosmical origin of the shooting stars are founded chiefly on their periodical recurrence at certain epochs of the year, and the extraordinary displays of the phenomena in various years on the nights of the 12th or 13th of November. We shall here merely state the principal circumstances accompanying those of 1799, which put the notion of a *lunar* origin entirely out of the question.

On the morning of the 12th of November, 1799, before sunrise, Humboldt and Bonpland, then on the coast of Mexico, were witnesses to a remarkable exhibition of shooting stars and fire-balls. They filled the part of the heavens extending from due east to about 30° towards the north and south. They rose from the horizon between the east and east-north-east points, described arcs of unequal magnitude, and fell towards the south; some of them rose to the height of 40°, all above 25° or 30°. Many of them appeared to explode, but the larger number disappeared without emitting sparks: some had a nucleus apparently equal to Jupiter. This most remarkable spectacle was seen at the same time in Cumana, on the

borders of Brazil, in French Guiana, in the channel of Bahama, on the continent of North America, in Labrador, and in Greenland; and even at Carlsruhe, Halle, and other places in Germany, many shooting stars were seen on the same day. At Nain and Hoffenthal in Labrador, and at Neuhernhut and Lichtenau in Greenland, the meteors seem to have approached the nearest to the earth. At Nain they fell towards all points of the horizon; and some of them had a diameter which the spectators estimated at half an ell. (Humboldt's *Recueil des Voyages, &c.* vol. ii.)

The second great meteoric epoch is the 10th of August, first pointed out by M. Quetelet; and although no displays similar to those of the November period have been witnessed on this night, there are more instances of the recurrence of the phenomena. In the three years 1838, 1839, 1840, shooting stars were observed in great numbers both on the 9th and 10th; but they appear in general to be unusually abundant during the two first weeks of August. The other periods which have been remarked are the 18th of October, the 23rd or 24th of April, the 6th and 7th of December, the nights from the 15th to the 20th of June, and the 2nd of January.

Halley first suggested the idea that the shooting stars may be observed as signals for determining differences of longitude by simultaneous observations; and Maskelyne in 1783 published a paper on the subject, in which he calls the attention of astronomers to the phenomena, and distinctly points out this application. The idea was revived by Benzenberg in 1802; but so long as they were regarded merely as casual phenomena, it could scarcely be hoped that they would be of much use in this respect to practical astronomy. As soon, however, as their periodicity became probable, the phenomena acquired a new interest; and some recent attempts to determine longitudes in this manner have proved that the method is not to be disregarded. In fact, most of our most recent knowledge of the star-showers has been acquired by systematic observation of them at places some distance apart, telegraphically connected. See an interesting paper on this subject by Dr. Olbers, in Schumacher's *Jahrbuch* for 1837; also the *Annuaire du Bureau des Longitudes* for 1836; *Mém. de l'Acad. de Bruxelles* for 1838; Schumacher's *Astronomische Nachrichten*, vols. xvi. and xvii.; and general papers communicated during 1863, 1864, and 1865, by Mr. Newton to *Silliman's Journal*, and by Mr. Herschel to the *Monthly Notices of the Astronomical Society*.

Shore. In Architecture, a piece of timber or other material placed in such a direction as to prop up a wall or other heavy body.

Shorea (after Sir J. Shore, governor-general of Bengal). This tropical Asiatic genus belongs to the order *Dipteraceæ*, and consists of large resinous trees, with entire or wavy-edged leaves, and axillary and terminal panicles of sweet-smelling yellow flowers. *S. robusta*, the Saul or Sál, is a native of India, extending from the provinces of Bengal and Behar to the foot of the Himalayas within the limits of the tropics. It is a magnificent and most important timber-tree, frequently attaining a height of upwards of a hundred feet. The wood is of a light-brown colour, close-grained, strong and durable, and is extensively employed in India, both by the natives and by Europeans, for shipbuilding, engineering, and other purposes where great strength and toughness are requisite. It is stronger, and at the same time much heavier than Indian teak. An oil is obtained from the seeds. Part of the resin known as Dammar is likewise obtained from this and other species of *Shorea*.

Shores (Dutch schoor). Strong props, used in shipbuilding, to keep the vessel steady on the slip. They are placed under the wales of the ship's bottom. *Breast-shores* are similar props used when a completed vessel is docked.

Short Page. In Printing, a page short of its full quantity of matter, such as those at the ends of chapters, or at the end of a book.

Shorthand Writing. [STENOGRAPHY.]

Shortstuff. In Shipbuilding, thin planks fastened over the ribs on the inside between the portholes.

Shot (A.-Sax. scyt). Any solid PROJECTILE.

Shot Lockers. Long pieces of wood pierced with holes like cups, in which the shot are placed, along the sides and round the hatchways.

Shoulder (A.-Sax. sculdre, Ger. schulter). In Fortification, the angle of a bastion included between the face and flank.

Shoulder Blade. The *scapula*, or pleurapophysial element of the pectoral arch.

Shoulder-of-Mutton Sail. A triangular sail used in small vessels as an auxiliary to prevent leeway. It is mounted on a temporary mast at the stern, its base being extended on a beam, and its apex against the mast. No gaff is employed.

Shoveller. The name of a species of duck, remarkable for the length and terminal expansion of the shovel-like bill; whence the name of *Spathulea*, proposed for the subgenus of which it is the type. It is the *Anas clypeata* of Linnæus.

Shrapnel Shells. In Artillery, a shell invented by General Shrapnel of the Royal Artillery. The projectile originally consisted of a thin iron shell filled with balls, sufficient powder being inserted with the balls to cause, when ignited by the fuse, the bursting of the shell; it was designed to act as case or grape at longer range than was attainable by those projectiles. Hence it was also called *spherical case shot*. The essence of the shell's construction is that the bursting charge should be so small as merely to open the shell, allowing the bullets to continue in flight with unimpeded velocity. *Improved Shrapnel shells* had the bursting charge separated from the balls by being placed in a cylinder in the middle of the shell. In the *diaphragm Shrapnel shell* the

powder is separated by an iron diaphragm from the bullets, all space between which is filled up with coal-dust. Shrapnel shells should burst about fifty yards short of the object, and should not be fired at very long ranges, or the bullets will not have sufficient velocity. .

Shrew. A small insectivorous mammal, some species of which are aquatic. [SOREX.]

Shrike. A name for the *Butcher birds*, or species of *Lanius*.

Shrine (Ger. schrein; Lat. scrinium, *a desk or cabinet*; whence also *screen*). Properly, the receptacle of the remains or relics of a saint. Shrines are of two sorts: portable, used in processions, called in Latin *feretra*; and fixed in churches. The appropriate place for shrines, in the churches of the middle ages, was generally in the eastern part, in the space behind the high altar. Such is the situation of the celebrated shrine of the three kings of Cologne; and such was that of the shrines at St. Albans, Canterbury, Durham, and Westminster, before the Reformation. (*Archæologia*, vol. i.)

Shrouds (A.-Sax. scrud). The large ropes supporting a mast laterally; they take the names of their respective masts, as *main-shrouds, fore-topmast-shrouds, mizen-topgallant shrouds*, &c.

Shrove Tuesday. The Tuesday after Quinquagesima Sunday, and immediately preceding Ash Wednesday; so called from the Anglo-Sax. shriven, *to confess*, because on that day confession was made preparatory to the fast of Lent.

Shrub (A.-Sax. scrob, Ger. schroff, *rough*). In Botany, a small low dwarfish tree, which, instead of one single stem, frequently puts forth from the same root several sets or stems.

SHRUB. The name given to a species of sweet wine or liqueur, of which rum forms the chief ingredient.

Shuttle (Icelandic skutul). An instrument used by weavers, which guides the thread it contains, so as to make it form the woofs of stuffs, cloths, linen, and other fabrics, by throwing the shuttle alternately from left to right and from right to left across between the threads of the warp, which are stretched out lengthwise on the loom. In the middle of the shuttle is a kind of cavity, called its eye or chamber, in which is enclosed the *spoul*, which is part of the thread destined for the woof.

Shwan Pan. The calculating instrument of the Chinese. It is similar in shape and construction to the Roman abacus, and is used in the same manner. [ABACUS.]

Si. In Music, the French and Italian name for the seventh sound, added by Le Maire, a Frenchman, at the latter end of the seventeenth century, to the six ancient notes, ut, re, mi, fa, sol, la, of Guido. It corresponds to our B.

Sialagogue (Gr. σίαλον, *saliva*; ἀγωγός, *a leader*). Medicines which increase the flow of saliva.

Sibbens. A disease endemic in some of the western parts of Scotland, somewhat resembling the yaws, and propagated by direct application of the contagious matter.

Siberite. A synonym of Rubellite or Red Tourmaline, the finest specimens of which have been found in Siberia.

Sibyl (Gr. Σίβυλλα). The name given to certain prophetic women said to have lived in Greece and Italy. Some authors recount as many as ten of them. The most celebrated were the Sibyl of Cumæ, fabled to have been consulted by Æneas, and the prophetess who is said to have offered her books to Tarquin the Proud. (*Mém. de l'Acad. des Inscr.* vol. xxiii.)

Sibylline Books. Documents supposed to contain the fate of the Roman empire. Nine of them are said to have been offered by an old woman, called Amalthæa, to Tarquin the Proud; but Tarquin refusing to give the price which she asked, she went away, and burnt three of them. Returning with the remainder, she offered them to the king on the same terms as before; and on his second refusal departed again, and returned with three, which she still offered at the same price as the original nine. The king, struck with her conduct, at last acceded to her offer, and intrusted the care of the books to certain priests (the quindecemviri). The story runs that they were preserved in a stone chest beneath the temple of Jupiter Capitolinus, being consulted in times of public danger or calamity, and that they were destroyed by the fire that consumed the Capitol in the Marsic war. After this calamity, ambassadors were sent to collect such fragments of Sibylline prophecies as they could pick up in various countries; and from the verses thus collected Augustus formed two new books, which were deposited in two gilt cases in the temple of the Palatine Apollo. Sibylline verses are often quoted by Christian writers, as containing prophecies of Christianity; but these were composed during the second century of the Christian era.

Sicilian Earth. A name sometimes given to fossil bezoar, which appears to be of a similar character to Armenian Bole.

Sicilian Vespers. In Modern History, the name commonly given to the great massacre of the French in Sicily, in A.D. 1282. They were the soldiers and subjects of Charles of Anjou, who had made himself master of the island after the defeat and death of Conradin. The insurrection broke out on the evening of Easter Tuesday. Its consequence was the expulsion of Charles; and the islanders placed themselves under the protection of the king of Arragon.

Sick-bay. On Shipboard, a portion of the main-deck partitioned off for invalids. It is usually in the bow. The partitions are easily removed, and in time of action, in a man-of-war, the sick-bay is transferred to the cockpit.

Sida (Gr. σίδη). An extensive genus of *Malvaceæ*, many of the species of which are used medicinally. The root of *S. acuta* is esteemed by the Hindus as a valuable stomachic, and is administered in ague, dysentery,

and as a remedy for snake-bites, while the leaves are used as a poultice, as likewise are those of *S. retusa*, *S. stipulata*, and *S. mauritiana*. Others are used in cases of rheumatism, and as an application in cases of the stings of wasps and other insects. The wood of these trees is extremely light; that of *S. micrantha* is used to make rocket-sticks in Brazil, where large quantities are employed on fête-days at the doors of the churches. The Chinese cultivate *S. tiliæfolia* for the sake of the fibre of its bark, which they prefer to hemp.

Side Keelsons. In large ships, keelsons parallel to, and somewhat smaller than the principal keelson, and distant about six feet from it. They extend from fifteen to twenty-five feet fore and aft of the main-mast, and are bolted through to the outside planking. The object is to give additional support to the ship's frame in the part adjoining the principal mast, and consequently the point of greatest strain.

Side Lever. The part of a certain species of marine engine which communicates the motion from the side rods to the cross tail, and which answers to the working beam in land engines. [STEAM ENGINE.]

Side-saddle Flower. One of the names of the curious pitcher-bearing genus of plants, called *Sarracenia* by botanists.

Sidereal System. [STAR.]

Siderite (Gr. σίδηρος, *iron*). Sparry Iron-ore, or native carbonate of iron. The term Siderite has also been applied to a vitreous variety of Quartz of an indigo or Berlin blue colour, from Golling near Salzburg.

Siderocalcite (a word coined from the Gr. σίδηρος, and Lat. calx, *lime*). The name given by Kirwan to the *Brown Spar* of Werner.

Sideroschistolite (Gr. σίδηρος; σχιστός, *cleavable*; and λίθος, *stone*). A hydrated silicate of iron, found in small six-sided black prisms at Conghonas do Campo in Brazil.

Sideroscope (Gr. σίδηρος; σκοπέω, *I view*). An instrument for detecting minute degrees of magnetism in substances usually supposed to be non-magnetic—the name having reference to the hypothesis that the traces of magnetism so detected are due to the presence of atoms of iron. The apparatus proposed by Lebaillif, in which the object is accomplished by means of a very delicate combination of magnetic needles, is described by Pouillet, *Élémens de Physique*, and by Sir D. Brewster, 'Treatise on Magnetism' in the *Encyclopædia Britannica*.

Sideroxylon (Gr. σίδηρος, and ξύλον, *wood*). A genus of Sapotaceous trees, often of large size, distributed over both hemispheres, but rarely extending beyond the tropics. Its name is given in allusion to the very hard wood afforded by the various species. The woods of many widely different trees, however, are likewise called Ironwood, almost every country producing a hard wood to which that name is applied.

The fruits of *S. dulcificum* have, as the specific name denotes, an exceedingly sweet taste, and are one of the kinds known to the English residents in Western tropical Africa (where the plant is indigenous) by the name of Miraculous-berry, being eaten in order to counteract the acidity of any article of food or drink, their sweet flavour being retained by the palate for a considerable length of time. They are rather more than half the size of olives, and somewhat of the same shape. Among the natives they form an article of trade.

Siege (Fr. siége; Ital. seggia, Lat. sedes, *a seat*, from the setting down of an army before the beleaguered fortress). A Military term, denoting the carrying on of offensive works and operations in the attack of fortresses.

The nature of sieges has, at all times, depended upon the character of the defensive works, and the arms and projectiles in use. In the days of slings, bows, and simple walls, the attack was conducted under great disadvantages. The more concentrated the garrison, the more strength it possessed. The attack could be made only within a short distance of the walls, and always in a direction parallel to the front attacked. Escalade was the first means of attack attempted, and when it failed, wooden towers, higher than the walls, were brought against the latter; the battering ram and the mine were employed to effect a breach.

The adoption of gunpowder and cannon greatly simplified the attack, for the walls, which had hitherto sufficed for defence, were easily breached by the heavy projectiles hurled against them. It became necessary, therefore, to protect the walls, and devise new modes of defence. [FORTIFICATION.] These, again, demanded a new mode of attack, the besieger bringing an overpowering fire on such of the works of the fortress as could be seen, and under its cover advancing close to the fortress, where he raised high mounds of earth, on the top of which he placed batteries to sweep the interior of the defences. Under cover of this fire, he either assaulted the place or advanced to a nearer position from which the walls could be breached. The attack thus conducted was very tedious, owing to the enormous labour of raising the mounds of earth for the *cavalier batteries*.

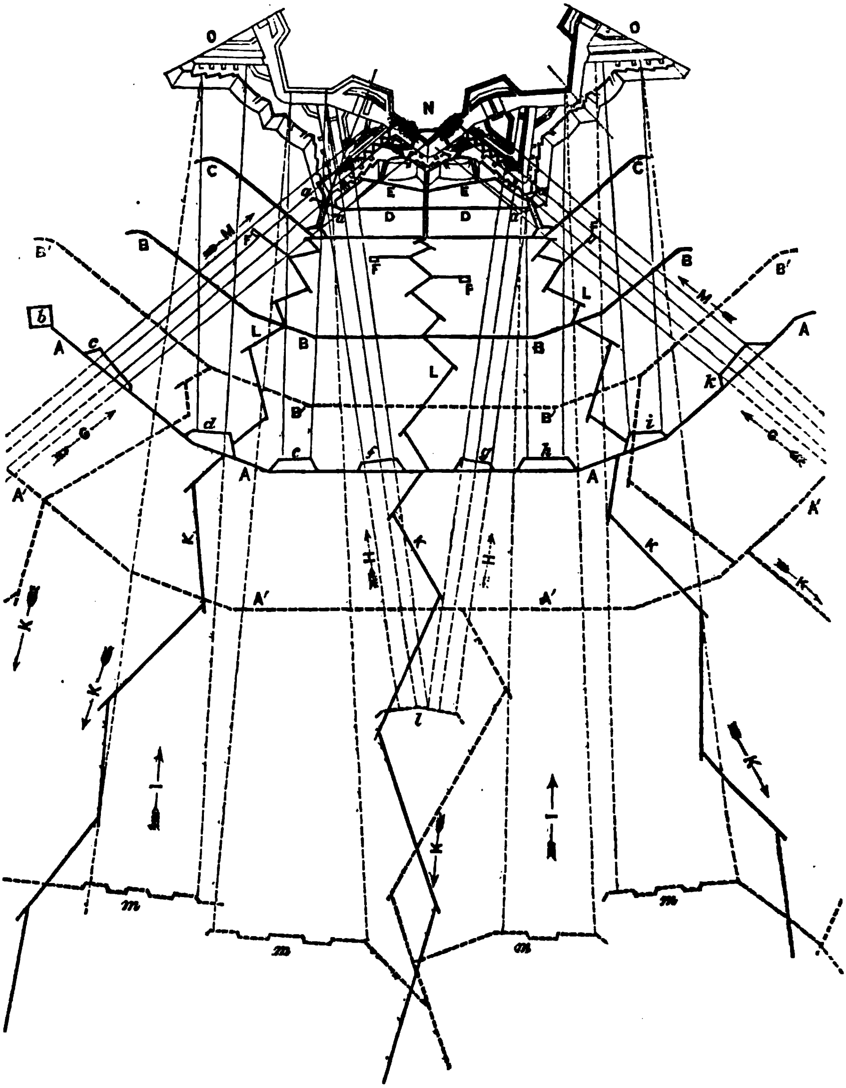
The genius of Vauban, however, by the invention of *ricochet fire*, and by modifying the ordinary siege works of the period, and combining them into a regular system of attack, shortened the duration of sieges, and gave them a certainty which they did not possess before.

The following sketch of a siege is based upon the practice of Vauban and other generals, and is supposed to be conducted against two ravelins and a bastion between them, of the modern French system, and with smooth-bore arms only, as no regular siege has been carried on since the introduction of rifled arms. The attacks on the small and feebly armed forts in America have been on too small a scale, and too irregular, to afford much information on regular sieges, and neither the Prussian nor Italian armies have undertaken the siege of

any Austrian fortress in the campaign of 1866.

The army advancing into the theatre of war for the reduction of a fortress, may be divided into two grand divisions, one for the actual siege, and the other called the *army of observation* or *covering army*, for operating in the field to prevent the interruption of the siege.

The besieging army may be subdivided into the investing corps and the attacking corps,



A' A' and A A. First parallels. A' A' extend to right and to left about 300 yards beyond margin. B B' and B B. Second parallels. C C. Third parallel. D D. Fourth parallel. E E. Fifth parallel. F F. Demi-parallels. G. Range 1,400 yards from batteries similar to *l*. H H. Range 1,400 yards. I I. Range 2,000 yards. K. Communications to Dépôts, Camps, &c. L L. Zigzags or approaches. M M. Range 600 yards. N. Attacked bastion with breaches. O. Similar works all round to complete Fortress. *a a.* Trench cavaliers. *b.* Redoubt. *c.* Enfilade battery, 12 guns. *d.* Counter battery, 12 guns. *e.* Counter battery, 14 guns. *f.* Enfilade battery, 7 guns. *g.* Enfilade battery, 7 guns. *h* Counter battery, 16 guns. *i.* Counter battery, 14 guns. *k.* Enfilade battery, 12 guns. *l.* Enfilade batteries. *m.* Small detached counter battery.

N.B.—The continued lines represent an attack with smooth-bored guns; the dotted lines an attack with rifled guns.

this latter furnishing the working parties and the guards of the trenches, to protect them from sorties. The investment [INVESTMENT OF A FORTRESS] is established suddenly and secretly, and is maintained rigorously throughout the whole siege, otherwise the fortress might be relieved, and the siege either prolonged or rendered hopeless. While the investment is being established, officers of the staff and engineers are employed in making and verifying plans of the fortress and adjacent ground, and in collecting every information bearing upon the proposed attack. This is called *making the reconnaissance*, and in doing so great care must be taken not to let the enemy know where it is proposed to attack the fortress, but, on the contrary, to endeavour to convey a false impression, this mistaken idea being often further carried out by the prosecution of a false attack for a considerable period.

The front most susceptible of attack having been selected, a project of attack is designed, which, however, can rarely be carried out in its integrity. The artillery park and the engineer dépôt are then placed conveniently, and out of sight and range of the fortress.

On the night in which ground is broken or the trenches opened, the *first parallel* or trench, to serve as a covered road and to protect the guards, is traced and constructed parallel to the works of the fortress, at a distance from them of from 400 to 800 yards, and extending on flank far enough to cover the most exposed batteries. During the same night trenches of communication are carried from the dépôts to the parallel, traced in *zigzags*, so that the enemy cannot see along their interior. All the parallels, communications, and approaches, are about three to four feet deep, and ten feet wide.

During the next few nights the batteries are constructed and armed, and in all possible cases enfilade batteries are employed to fire *en ricochet*. Three or four guns so placed, and sending their shot bounding along the face of the enemy's works, will dismount or disable all the guns on the face enfiladed. When it is impossible to have enfilade batteries, direct or counter batteries are constructed, replying with one or two guns to every gun mounted on the face to be silenced. When these batteries have in a great measure silenced the artillery fire of the fortress, a *second parallel* is constructed about half-way between the first parallel and the fortress, and communications made between the parallels by zigzags.

When the artillery fire of the place has been completely silenced, the approaches are pushed on by sapping, a very slow process, the advance depending on the rate at which the sapper, at the head of the sap, can work, rolling on before him the covering sap roller, and placing the gabions to be filled with earth. When the heads of these approaches are too far advanced from the parallel for proper support, short trenches called *demi-parallels* are pushed out right and left, and guards of the trenches placed in them. The approaches are again pushed on to within about 120 yards of the covered way, where the *third parallel* is constructed, connecting the heads of the attacks. The next object to be attained is the *crowning of the covered way* of the ravelins; i.e. the formation of a trench or lodgment along the edge of the glacis, that position being reached either by systematic approach, or by the hazardous operation of assault, in which a storming party drives the defenders out of the covered way, a working party following with the necessary tools and materials to form the lodgment outside the covered way.

In the advance by systematic approach, saps are driven direct upon the salients of the covered way to about forty yards from the salients, where raised musketry parapets or *trench cavaliers* are constructed to enfilade the covered way. A *fourth parallel* connects the two inner cavaliers. The saps are again pushed on to within twenty feet of the salients, where they branch out right and left, forming the lodgment on the glacis or crowning of the covered way. A *fifth parallel* connects the inner ends of these lodgments. Batteries are then formed in these lodgments to breach the ravelins and silence the flanking fire of their ditches. A *great gallery of descent*, for the passage of the storming parties, is driven underground from the lodgment into the ditch (opposite the breach) across which a sap is driven; the breach is captured and crowned with a lodgment; and saps made across the salient of the ravelin, from which guns and muskets keep down the fire of the place.

The redoubt of the ravelin is breached by mines, and when this work falls the covered way in front of the bastion may be crowned, without fear of these lodgments being seen into from the redoubt. Batteries are formed in these lodgments to oppose the flanking fire of the main ditch to be crossed. Saps are pushed on in the redoubts of the ravelins until the *coupures* of the ravelins are taken in reverse, when, the enemy abandoning them, they are taken possession of, and from them the redoubts in the covered way are taken in reverse, and these being abandoned are occupied and furnish sites for the principal breaching batteries, others being likewise constructed outside the redoubts. While these batteries are breaching the main escarp, saps are driven to the edge of the main ditch, the walls of which are mined, access being thus given to the main ditch, across which saps are driven to the breaches, which on being captured are crowned, and thus the salient of the bastion is taken possession of. The place may then be said to have fallen; for if the besieged have constructed any retrenchments inside, they will soon be reduced by similar operations or by assault.

These works, if carried on without interruption, would occupy about forty nights.

As to the future of sieges, the balance of professional opinion is decidedly in favour of the defence, under the assumptions that iron in the form of cupolas, shields, and plates is available, as well as large rifled guns carrying elongated

shells with large bursting charges. There can be no doubt but that great delay will be caused, for the siege works must be commenced much farther off, and the besiegers' first batteries will be repeatedly blown to pieces with large shells during their attempted construction.

If the fortress can preserve a few guns in cupolas or behind shields, it will be impossible to sap, at least by day, unless the sap be made nearly twice as deep as heretofore, adding thereby immensely to the labour and causing delays.

Mining may be resorted to, but even with the aid of machinery it must always be a slow and precarious method.

The circumstances under which a strong fortress, amply provided for defence, could be successfully besieged, would appear to be:—

1. Extensive and uninterrupted railway or maritime communication.

2. A lavish supply of large rifled ordnance.

3. An army large enough to supply the extensive working parties which in future will be necessary.

As to the attack of fortresses of the polygonal or German system, it would appear that their reduction will present greater difficulties and delays than in the other systems, for they will offer none of their principal faces for enfilade; they will bring a more powerful fire on the field of attack, which fire must be met with counter batteries, and the well-preserved powerful flanking fire for the main ditch will be very difficult to subdue at the critical part of the attack.

One grand feature of future sieges will undoubtedly be the placing of guns in a large number of small batteries, instead of crowding the guns into a few large batteries. The advantage also which the cover of night afforded to the attacker will in a great measure be neutralised by means of the powerful light which modern science will throw on the field of attack, to disclose the besiegers' operations.

Finally, if it be conceded that sieges, in future, must be of considerably longer duration than formerly, it would follow that many fortresses, although not absolutely impregnable, will virtually become so, from the impossibility of devoting the necessary time to their reduction in ordinary campaigns.

Siege Train. The combination of artillery, both men and material, formed for the conduct of a siege.

Siegenite. A name for Cobalt Pyrites, after Siegen, one of its localities. [LINNÆITE.]

Sienna and Raw Sienna Earth. [TERRA DI SIENNA.]

Sierra (Lat. serra, *a saw*). A Spanish term, signifying a chain of hills, and prefixed to the names of several places in Spain, and other parts discovered or colonised by the Spaniards.

Siesta (Span.). The name given to the practice indulged in by the Spaniards, and the inhabitants of hot climates generally, of resting two or three hours in the middle of the day, when the heat is too oppressive to admit of their going from home.

Sifrit. In Mythology. [SIGURDR.]

Sigaultian Operation. The division of the *symphysis pubis*, for the purpose of increasing the capacity of the pelvis in cases of impracticable labour. It was first performed by a French surgeon of the name of Sigault, but is now discarded.

Sight. [VISION.]

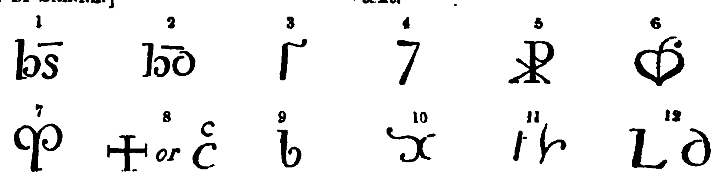
Sights for Ordnance. Pieces of wood or metal attached to a gun, in order to *lay* the gun accurately, by bringing them in line with the object aimed at. The hind sight is always capable of being raised so as to vary the angle of elevation of the gun to the exact extent required. [GUNNERY.] Smooth-bored land-service cast-iron guns are provided with *Millar's sights*, consisting of a graduated tangent scale at the breech, and a dispart sight in front of the second reinforce. A wooden tangent scale is also supplied, and used for elevations over the *clearance angle*.

The rifled guns in our service are provided with a *barrel-headed tangent sight* and a *trunnion sight* on each side of the gun. The *barrel-headed sight*, instead of rising in a vertical plane, as with a smooth-bored gun, rises at an angle to the left from the vertical, in order to allow for the *derivation* of the shot. [PROJECTILE.] The larger rifled guns have also centre-sights.

The radii to which the metal tangent scales are graduated are the distances from their heads to the dispart or trunnion sight, but the wooden tangent scales are graduated to the long radius, or the notch on the muzzle.

Sigillaria (Lat.). Fossil plants found in the coal formation. They are represented mainly by the stems, which have leaf-scars, like seal-impressions: whence the name of the genus.

Sigla. In Printing and in ancient MSS., notes, breviatures, letters used for words, characters or shorthand. Some specimens of the sigla of the sixth, seventh, and eighth centuries are here given. Some of them were invented by the writers themselves, or afterwards by others in illustration of the text.



1. H.S. i.e. Hic suppleas, or hæc supplenda.
2. H.D. i. e. Hoc deficit, or hæc deficiunt.
3. Paragraphus, a note of division.
4. Diple, to mark out a quotation from the Old Testament.
5. Crisimon, being composed of X and P, which stands for Christ. [LABARUM.]
6. Hederacei folii figura, an ivy leaf, the ancient mark of division.
7. Ancora superior. To denote a very remarkable passage.
8. Denotes the beginning of a lesson.
9. Signifies good.
10. Stands for something very kind, or benevolent.
11. Points out a fine or admirable passage.
12. L.D. *lepide dictum*. Finely said.

(See Octavius de Strada, Negitius, Frontinus, and Johannes Nicholaus.)

Sign (Lat. signum). In Algebra, a symbol indicating an operation to be performed, or a relation subsisting between two quantities. Of the former kind, those most commonly used are, + for addition, − for subtraction, × for multiplication, ÷ for division, $\sqrt{}$ for the square root, $\sqrt[3]{}$ for the cube root, $\sqrt[n]{}$ for the nth root, &c. The signs denoting relations are, = equal to, > greater than, < less than, &c.

SIGN. In Astronomy, a portion of the ecliptic or zodiac, containing thirty degrees, or a twelfth part of the complete circle. The first commences at the point of the equator through which the sun passes at the time of the vernal equinox; and they are counted onwards, proceeding from west to east, according to the annual course of the sun, all round the circle. The names of the twelve signs, in the order in which they follow each other, with the characters by which they are indicated on globes, and in the almanacks and books of astronomy, are as follows: *Aries* ♈, *Taurus* ♉, *Gemini* ♊, *Cancer* ♋, *Leo* ♌, *Virgo* ♍, *Libra* ♎, *Scorpio* ♏, *Sagittarius* ♐, *Capricornus* ♑, *Aquarius* ♒, *Pisces* ♓.

It is to be remarked, that the above are also the names of the twelve constellations of the zodiac; and in ancient times (above 200 years before our era), the places of the signs and the constellations were coincident; but owing to the motion of the earth's equator, by which the equinoctial points are carried backwards on the ecliptic about 50·6″ annually, the intersections of the ecliptic and equator, and consequently the commencement of the signs, now correspond to different stars, the first point of the sign Aries being at present near the beginning of the constellation Pisces. On this account care must be taken not to confound the signs of the zodiac, which are fixed in respect of the equinoxes, with the constellations, which are movable in respect of those points. [CONSTELLATION.]

The *ascending signs* are the six beginning with Capricornus, through which the sun passes while advancing from the winter to the summer solstice, and is, consequently, acquiring altitude with respect to inhabitants of the northern hemisphere. The other six, beginning with Cancer, are called the *descending signs*.

SIGN. A picture hung in front of inns; a remnant of a custom which formerly prevailed with regard to shops in general.

Sign, Botanical. [SYMBOLS, BOTANICAL.]

Sign Manual. The royal signature, superscribed at the top of bills of grants or letters patent; which are then sealed with the privy signet or great seal, as the case may be, to complete their validity. But there are some grants which pass through certain offices, as the Admiralty or Treasury, under the sign manual only.

Signal Light. [BLUE LIGHT.]

Signals. [TELEGRAPH.]

Signals, Naval. A system of symbols addressed to the eye—as flags, boards, lights, &c.—for establishing communications at distances too great for the voice. Guns are also used for the same purposes. The first signals seem to have been merely distinguishing flags for certain ships. In the system instituted by James II. for orders to the fleet, the purport depended on the part of the ship at which they were exhibited; a condition very detrimental to the use of signals at sea. A code composed of *numeral* flags and pendants, i.e. in which each combination of numbers had a verbal expression assigned to it, seems to have been the first step towards a general system, as before this plan each admiral instituted his own code. In 1815, Sir Home Popham's code was adopted. This added several *literal* or alphabetical flags and pendants, which greatly extended the means of communication, but necessarily rendered the signals indistinct, and their purports deceitful, in many cases, from the increased difficulty of distinguishing each flag from the rest. In 1826, in consequence of some plans having been submitted by admirals for a more efficient system, the code still partly in use, which was considered as an improvement on its predecessor, was adopted. In 1828, Admiral Raper published his code, which was one of those under consideration. The principle of this system was that the manner of combination of the flags and pendants of which the signal is composed, i.e. their order or arrangement, should point out the subject of the signal, or, as the author terms it, the *point of service* to which the signal relates; while the *numbers* of the individual symbols indicate the number of the signal in its class. The numbers are denoted, as usual, by the colours; but when these fail, from haze or distance, the number is supplied by *numeral distant signals*. From the distinctness attending the small number of symbols (the smallest possible for complete numeral signals), the precision obtained from classification by which the simplicity of each signal is proportioned to its importance, and the saving of the time often wasted in vain attempts to distinguish the precise disposition of the colours

of each flag, this system has been considered by some competent judges as the sole thoroughly efficient method.

In the merchant service, signals are of less extensive utility than in the royal navy, their chief employment being to express the names of vessels, latitude and longitude, and a few other such particulars. Attempts have been made by the principal maritime governments to establish a universal code of signals for the mercantile marine of all nations.

The colours of flags are rather a drawback to their usefulness, as at a distance signalmen find it hard to distinguish between blue, red, and black, or between yellow and white. Some modern systems have therefore been tried with only black and white in the flags. This, of course, diminishes the number of symbols. But flags, generally, are subject to the objection of indistinctness. On a still day they will not extend at all; on a windy day they may happen to extend in a direction end on to the observer, when of necessity they will be unintelligible. Solid figures, of canvas on iron frames, have been tried; but the cone, sphere, cylinder, and cube, are the only figures which presented the same appearance in every direction. The reduction in the number of symbols renders a *code* desirable. With many flags hung one above another it is easy to spell a word, and this is known as *word signalling*, but with few symbols—the nine numerals, 0, and two repeaters for instance—it saves much time if a combination of four symbols be taken arbitrarily to represent a word or common sentence. This is a code. The symbols named above are sufficient to communicate 14,000 words and phrases; and they constitute the basis of the code adopted by the Admiralty and the Board of Trade. In addition to other advantages over word-signalling, the code has the gain of being applicable to any signals—flag, telegraph, flashes, &c.—and the numbers, representing not spelling of words but the idea embodied in those words, are equally applicable in all languages. The next competition is between signalling and telegraphing; in the former the whole word or combination of numerals is exposed at once, while, in the second, one letter or numeral is shown at one motion. At first sight the former seems the quicker mode; but the preparatory arrangements take longer, more apparatus is requisite (at least twelve different signs being indispensable) than with the telegraph, where four signs, each of which can be shown affirmatively or negatively, answer all the purposes. The simplicity of the telegraph system will certainly make it general before long.

Having shown that word-signals must yield to codes, and that codes can be better communicated by telegraphing than signalling, it is only necessary to show the various apparatus used for the latter. The oldest of the modern telegraphs is the *arm* telegraph, still used on railways; here a post with two revolving arms can make any signal. It is, however, only visible at a point in front or nearly in front. The great improvement was Redl's cones, consisting of four black cones on a mast. Each cone is constructed like an umbrella, and, by means of a spring, its normal position is closed tight upon the mast. By a cord from each cone, the operator can open it at will, and keep it in an open position as he pleases. The cones represent four positions—open, positive; shut, negative. By combinations of these, all the symbols for telegraphing are obtained. The signs can be changed with the utmost rapidity; the mast is light, and easily removed from one point to another; it forms a ready communication from ship to shore, between portions of armies, or indeed in any situation, as the signals appear the same in every direction. For day telegraphing these cones have now been universally adopted in the British service. Several ingenious officers—and notably Captains Bolton and Colomb—have developed the system of the cones to any signs whatever which admit of four positions and a positive or negative aspect. Thus, two men's arms extended or by their sides; one man raising an arm, with or without a handkerchief, four times in quick succession; four notes on a horn or steam-whistle—long notes for positive, short notes for negative—constitute a telegraph ready for use. Many experiments have been made to try the most efficient symbols for distant telegraphy. The results have given the preference for day signalling to jets of steam, long or short, and for night purposes to the flashes of a strong light. For this latter purpose the light is covered by a shade and exposed $1\frac{1}{2}$ seconds for a positive signal and half a second for negatives. Four puffs of steam or flashes of light constitute a symbol, and four symbols one phrase or word, as shown by the code. It is needless to point out that these time-signals are precisely on the principle of Morse's electric telegraph.

'Steam-jet,' 'Flashing,' 'Sound,' or 'Electric Telegraph Time-signals,' representing the symbol 3,591, to which an arbitrary meaning is attached.

Signature (Lat. signatura). In Music, the flats and sharps placed after the clef, at the beginning of the staff, which affect, throughout the movement, all notes of the same letter.

SIGNATURE. In Printing, a letter of the alphabet placed at the bottom of the first page of each sheet of a work, to denote, alphabetically, the order of the sheets.

It is customary to commence with B on the first sheet of the body of the work, and to go regularly through the alphabet, with the exception of the letters J, V, and W, which are never used as signatures, and which had,

in fact, no existence in the alphabet at the time of the invention of printing; 𝕴 expressing both I and J; 𝖀, both U and V; and 𝖂, the double letter W. If the work extend to more sheets in number than there are letters in the alphabet, the succeeding sheets go on with a second alphabet, which commences with A, and both the letters are usually given; in this manner, A A, or A a, and sometimes, to avoid the repetition, thus, 2 A. If a third alphabet be necessary, it is always, at the present day, placed with the number before it, as 3 A. The printer's first alphabet consists of twenty-two letters, and the second and succeeding ones of twenty-three.

As a guide to the bookbinder, there are other signatures used in a sheet besides the first. In a sheet of octavo it was till recently usual for the first page to have B, the third B 2, the fifth B 3, and the seventh B 4: in a sheet of twelves they were carried to B 6, B 5 being the first page of the offcut; and however numerous the pages may be in a sheet with one signature, when they were all inserted, they were continued to the last odd page before the middle of the sheet, but never carried beyond the middle. In general they were all omitted except the first two, to show the first fold of the paper, and the first on the offcut. Small capitals are more frequently used for signatures than large capitals, as disfiguring the foot of the page in a slighter manner. Sometimes figures are used instead of letters, but not often; the *Gentleman's Magazine* is an instance.

No. of Sheets	Signature	Folio	No. of Sheets	Signature	Folio	No. of Sheets	Signature	Folio
			23	2A	353	46	3A	721
1	B	1	24	B	369	47	B	737
2	C	17	25	C	385	48	C	753
3	D	33	26	D	401	49	D	769
4	E	49	27	E	417	50	E	785
5	F	65	28	F	433	51	F	801
6	G	81	29	G	449	52	G	817
7	H	97	30	H	465	53	H	833
8	I	113	31	I	481	54	I	849
9	K	129	32	K	497	55	K	865
10	L	145	33	L	513	56	L	881
11	M	161	34	M	529	57	M	897
12	N	177	35	N	545	58	N	913
13	O	193	36	O	561	59	O	929
14	P	209	37	P	577	60	P	945
15	Q	225	38	Q	593	61	Q	961
16	R	241	39	R	609	62	R	977
17	S	257	40	S	625	63	S	993
18	T	273	41	T	641	64	T	1009
19	U	289	42	U	657	65	U	1025
20	X	305	43	X	673	66	X	1041
21	Y	321	44	Y	689	67	Y	1057
22	Z	337	45	Z	705	68	Z	1073

Signatures, Doctrine of. A belief held by some ancient physicians and pharmaceutists that every natural substance which possesses medicinal virtue, indicates, by an obvious external character, the disease for which it is a remedy, or the object for which it should be employed. Hence, it was assumed that poppies must relieve diseases of the head, from the form of their seed-vessels; turmeric, being yellow, must cure jaundice; *cassia fistula*, intestinal disorders; groomwell (or lithospermum), gravelly disorders, from the polish and hardness of its seeds; and so on. Upon this principle it is probable that red cloth was held in estimation as an application to cutaneous eruptions, and that John of Gaddesden in the fourteenth century ordered the son of Edward I., who was attacked with smallpox, to be wrapped in scarlet cloth and lie in a room with scarlet hangings.

Signet, The Privy. One of the royal seals in England, used in sealing private letters and grants under the sign manual. It is in the custody of the Secretary of State for the Home Department. [Seal; Secretary.] The signet in Scotland is the seal by which the royal letters and writs for the purpose of justice are now authenticated. Hence, the title of clerks to the signet, or writers to the signet; whose business is nearly the same with that of attorneys in England. They were anciently clerks in the office of the Secretary of State, by whom writs were prepared; and when the signet became employed in judicial proceedings, they obtained a monopoly of the privileges of acting as agents or attorneys before the Court of Session.

Significant Digits of a Number. Those digits which remain after striking off all the ciphers on the right or left. Thus the signifi-

cant digits of 12300 are 1, 2, 3, and those of the decimal number ·00301 are 301. It is in logarithms that this distinction is usefully made. The logarithms of all numbers whose significant digits are the same have the same *mantissa* or decimal part, and differ only in their *characteristics*. The number of places, to the left or right of the unit's place, of the first (extreme left) significant digit gives, respectively, the positive or negative characteristic of the logarithm. [LOGARITHMS.]

Signor (Span. señor; Lat. senior, *elder*). The Italian term equivalent to the English *Lord*, *Sir*, or *Mr.*, the French *Monsieur*, and the German *Herr*. *Signoria* was anciently the appellation of the chief council of Venice, Genoa, and Lucca.

Sigurdr. In Northern Mythology, the great hero of the VOLSUNGA SAGA, which was afterwards expanded in the EDDA and finally remodelled in the lay of the NIBELUNGEN.

Sigurdr, in the tale of the Volsungs, is the son of Sigmund, born after his father's death. Sigmund, the son of Volsung, a descendant of ODIN, had gained possession of the sword Gram, which Odin in disguise had driven to the hilt in an oak trunk, and left for the man who was strong enough to draw it out. With this sword Sigmund overcomes every enemy, until, in a battle between him and the sons of King Hunding, Odin reappears in his old disguise and presents a spear on which the sword Gram is broken in twain. Sigmund then dies on the battle-field, and his wife Hjordis gives birth to Sigurdr, in the house of Hialprek, king of Denmark. This child, the favourite hero of Teutonic song, grows up into a manhood as majestic as that of PHŒBUS and Achilleus. [ILIAD.] His golden locks flow down over his shoulders, and gleam like the rays of the sun; his eye is bright and piercing, and his countenance full of splendour. He is the foster child of Regin (the smith of King Hialprek), who urges him on to slay the dragon Fafnir [PYTHON], who lay on the glistening heath, coiled round a heap of gold. But Sigurdr, bent first on avenging his father's death, asks Regin to forge him a new sword. The weapon snaps in his hand; and Sigurdr then obtains from his mother the broken bits of Gram, out of which Regin forges a new blade, the force of which nothing could withstand. Having slain the sons of King Hunding, Sigurdr attacks and slays Fafnir, thus becoming master of the golden treasure, and with it of a ring on which Andvari the dwarf had laid a curse, by which it should become the bane of every man who owned it. By eating Fafnir's heart, Sigurdr is also endowed with a marvellous wisdom, which enables him to understand the song of birds. Riding away with his spoil, he came to a lonely heath, in the midst of which a fierce flame surrounded a house, in which lay a fair maiden Brenhyldr, the daughter of Atli, in a sleep never to be broken until there came some one brave enough to ride through the flame. At the touch of Sigurdr, she wakes up, and Sigurdr, having plighted to her his troth, rides on to the house of Giuki the Niflung [NEPHELÊ], who determines that Sigurdr shall marry his daughter Gudrun. So Grimhildr, Giuki's wife, gave him a potion which caused him to forget Brenhyldr, and Gudrun becomes the wife of Sigurdr.

Meanwhile, Brenhyldr still waited the return of Sigurdr to rescue her from her captivity. Gunnar, the brother of Gudrun, having resolved to marry Brenhyldr, tries in vain to ride through the fire, and therefore Grimhildr by her magic arts made Sigurdr change shapes and arms with Gunnar, and so deliver Brenhyldr. On the bridal bed Sigurdr places his sword Gram between himself and Brenhyldr, to whom in the morning he gives the ring of Andvari, receiving from her another in return. Sigurdr then resuming his shape, hands Brenhyldr over to Gunnar; but no sooner has he done this than the power of the magic potion passes away, and he sees too late that he has betrayed his first love. At length, from Gudrun, Brenhyldr learns that she was rescued from the flame not by Gunnar, as she thought, but by Sigurdr; and, her love for the hero giving place to indignation at his treachery, she urges on Gunnar and his brothers to slay him. But they had sworn, as the gods had sworn in the case of Baldr, not to hurt Sigurdr. Hence, that which they would not do themselves, they incite their half-brother Guttorm to do for them. Thus was Sigurdr slain as he lay sleeping; but his death revives all the love of Brenhyldr, and lying down by the side of Sigurdr, with his good sword Gram between them, she dies heart-broken on his funeral pile. Then Gudrun, wandering away, becomes the wife of Atli (the brother of Brenhyldr), who claims the treasures won by Sigurdr from the dragon, but which the Niflungs had taken when Sigurdr was slain. Unable to gain them by force, Atli invites Gunnar and his brethren to a feast, and then ensnares them. Gunnar is thrown into a pit of serpents, one of which flies at his heart and stings him to death. Gudrun then, in revenge for the death of her brothers, first slays her children by Atli, and then kills her husband Atli himself. Weary of her life, she casts herself into the sea; but the sea will not let her die, and bears her to the land of king Jonakr, by whom she becomes the mother of three sons, who are all dark haired like the Niflungs, and a daughter, Swanhild, whom Hermanric seeks for his wife, sending his son Randver to woo her. Randver, instead of doing his father's bidding, seeks her for himself, and for this misdeed is put to death. Afterwards, seeing Swanhild washing her golden hair, Hermanric rides his horse over her, as the cause of all his troubles, and tramples her to death. Gudrun then bids her sons avenge their sister, and they slay Hermanric in his sleep, as Sigurdr had been slain by Guttorm. For this crime they are put to death; and, soon after, the weary life of Gudrun comes to an end.

This Teutonic myth has a double value, (1) as

throwing light on the mythology of other races, and (2) as enabling us to form a judgment on the quasi-historical character which some myths have assumed.

(1) It will probably be disputed by none, that if in two tales full of startling events two or three incidents should be found common to both, a certain connection may be inferred between the stories; and it may be assumed either that they are the work of the same writer, or if of two writers, that one borrowed from the other, or that both obtained their materials from one common source. If the number of these common incidents be multiplied, the presumption of a connection between the stories is indefinitely strengthened; and in proportion to the improbability that one writer borrowed from the other, the conclusion that they worked on a common stock of materials gathers force. But, if it be found that these common incidents have the same sequence, that the motives assigned to the actors in these tales, as well as their characteristic features, are in each case the same, it seems impossible to doubt that the tales have a common substratum; and as the idea that the authors of the Volsung tale borrowed their materials from the *Iliad* or the *Odyssey*, or that the Greek epic poets borrowed from those of Persia and India, is too wild to be entertained by any who have studied the conditions under which traditions are diffused, it follows that legends exhibiting the same features in common point to one and the same source, from which the tales have been carried in different directions, to receive in their distant homes a new local colouring, with modifications which must be the result of new geographical features and new conditions of soil and climate.

Some points of resemblance between the myth of Sigurdr with the myths of non-Teutonic peoples have been already pointed out. But the correspondence may be traced in almost every detail. If Odin leaves a sword which is to become the property of him who is able to draw it from the oak trunk, so Ægeus hides his weapons beneath a stone, which must be lifted by THESEUS before he can become possessed of his father's arms. The portrait of Sigurdr is also the portrait of Phœbus Apollo, of Achilleus and ODYSSEUS, of PHAETHON, Patroclus, and TELEMACHUS. From Hjordis, his mother, Sigurdr obtains the sword Gram, reforged by Regin the blacksmith, brother of the Danish king; from Thetis, Achilleus receives the armour which the smith HEPHÆSTUS had made, in place of that which Hector had stripped from the body of Patroclus. The vengeance taken by Sigurdr on the sons of king Hunding is the revenge taken by Achilleus on the Trojans for the death of his friend. His slaughter of Fafnir is the slaughter of Python by Phœbus, of the Minotaur by THESEUS, of the Libyan dragon by PERSEUS, of the Sphinx by Œdipus, of the snakes which HERACLES strangles at the outset of his career. The power granted to Sigurdr of understanding the voices of birds is granted also to Iamos, and Melampus is taught the same wisdom by serpents. If Brenhyldr sinks into a death-like sleep, after being wounded with a thorn by Odin, so is Isfendiyar, in the Persian epic, slain with a thorn by Rustem. Brenhyldr the maiden is PERSEPHONE, the Korê or Girl; like Persephonê, she is taken away from the world of the bright gods, and guarded in a dismal land, from which one hero alone can deliver her, as Andromeda can be rescued from the dragon only by the invincible Perseus. Brenhyldr, again, is the first love of Sigurdr; to her he plights his faith in the spring time of his life, and scarcely have they met before they must part. So was it with Iolê and Heracles, with Œnônê and PARIS, with Odysseus and Penelopê, with Brisêis and Achilleus. In these legends the relation of Gudrun to Brenhyldr is that of Deianeira to Heracles, of Helen to Paris once called Alexandros; and in each case the desertion is followed by vengeance. The 'wrongs and woes' of Helen roused the wrath of the Achæan chieftains; and the death of Paris answers to that of Sigurdr. In each case the deserted maiden reappears, forgiving and tender at the close. Œnônê cannot heal Paris, but like Brenhyldr she lies down on the fiery couch by his side; and Iolê stands by the funeral pile of Heracles on the rugged heights of Œta.

The remainder of the tale only repeats the story of Sigurdr in a modified form; and the same substantial repetition is seen in the tale of Ragnar Lodbrog, Aslauga, and Thora. In the traditional history, this Lodbrog, or Lothebrok, is said to have been murdered by Biorn, the huntsman of Edmund, king of the East Angles. With the historical character of this statement we are not here concerned; but it is significant that Ragnar wins his first wife Thora by delivering her from a dragon as Sigurdr rescued Brenhyldr. Ragnar Lodbrog is, again, a son of Sigurdr. After Thora's death, he woos Kraka, whom he is on the point of deserting for the daughter of Osten, when Kraka reveals herself as the child of Sigurdr and Brenhyldr (Thorpe's *Northern Mythology*, i. 108, 113); and thus the tale of Sigurdr and Brenhyldr is reproduced in that of Randver and Swanhild, as well as in that of Ragnar and Aslauga.

If a comparison of Teutonic with Greek and Aryan mythology supplies the key which unlocks the secret of this astonishing parallelism, the discovery may be welcomed as setting at rest many very perplexing questions and some disagreeable doubts. But the parallelism would nevertheless remain a fact, even if we were altogether unable to explain it. For the light thrown on the subject by comparative mythologists, the reader is referred to the articles MYTHOLOGY; LANGUAGE; POLYONYMY; SYNONYMY. It may suffice here to remark that Sigurdr, in his brilliant life and early death, in his desertion of his firstborn, in his physical features, in his matchless bravery and his invincible weapons, in the struggle which follows his marriage with Gudrun, and in the forgiveness of Brenhyldr when his offence has been atoned by his death, reproduces with singular

exactness the chief features in the myths of Apollo, Heracles, Meleagros, Bellerophon, Achilleus, Odysseus, Paris, Perseus, Theseus, Rustem, Kephalos, and other heroes. And, finally, it may be noted that the myth of the marriage of Gudrun with Atli exhibits in her jealousy and the slaughter of her children the closest parallelism to the myth of MEDEIA and Jason.

2. But the myth of Sigurdr, in its later developements, is (if possible) even more important, as showing the slender value which can be assigned to a legend, on the ground that it mentions names which we may know to be historical. Charlemagne is as much an historical personage as William III. or Sir Isaac Newton; and it may be asserted, that the myths which have gathered round his name preserve, amid many perversions, a certain groundwork of real history. But without the testimony of witnesses known to be contemporary, we could not distinguish between that which is and that which is not historical. Speaking of a battle fought against the Basques, Eginhard mentions among the slain, 'Hruodlandus Britannici limitis præfectus.' This is, probably, the Roland of chivalrous mythology, who fell at Roncesvalles. Knowing, thus, from other sources, that Charlemagne had an officer named Hruodland or Roland, we are, perhaps, able to say that the tales relating to Roland have gathered round a person of whom we know the name, but nothing more. But as soon as we leave the sure ground of historical testimony, the test is found to be delusive. The story of the Nibelungen Lay is essentially the same as that of the Volsung tale; but the names, still preserving a resemblance to those in the earlier saga, are in the later poem the names of persons whom we know to be historical. Thus, Gunnar becomes Gunther, a Burgundian king of the fifth century, who was conquered by the Huns of Attila. Hence, Atli, the brother of Brenhyldr, and the second husband of Gudrun, is changed into Attila; while Sigurdr has been identified with Siegbert, king of Austrasia, 'who was actually married to the famous Brunehault, who actually defeated the Huns, and was actually murdered by Fredegond, the mistress of his brother Chilperic.' 'This coincidence between myth and history,' remarks Professor Max Müller, 'is so great, that it has induced some euhemeristic critics to derive the whole legend of the Nibelung from Austrasian history, and to make the murder of Siegbert by Brunehault the basis of the murder of Sifrit or Sigurdr by Brenhyldr. Fortunately, it is easier to answer these German than the old Greek euhemerists, for we find, in contemporary history, that Jornandes, who wrote his history at least twenty years before the death of the Austrasian Siegbert, knew already the daughter of the mythic Sigurdr, Swanhild, who was born, according to the Edda, after the murder of her father, and afterwards killed by Jörmunrekr [Hermanric], whom the poem has again historicised in Hermanicus, a Gothic king of the fourth century.' (*Comparative Mythology*, 68.)

Now, here we have to note that we know the names of Gundicar, Siegbert, Dietrich of Bern, (=Theodoric who lived at Verona), Brunehault, Hermanicus, and others mentioned in the lay, to be the names of historical persons, only because we find them in authentic contemporary narratives; but from the *Nibelungen Lied* we do not learn even their names. If we had not obtained the knowledge from other sources, we could not have known from the poem that Siegbert ever lived, and could no more have been justified in saying that he was murdered, than we are now justified in saying that the coast of Kent witnessed the landing of Brute, the Trojan, on the shores of England. Hence, so far as the lay is concerned, Attila, Brunehault, and all the rest are mere names; while of the men themselves we know absolutely nothing.

If we apply this canon to the epics of the Homeric age, we find ourselves confronted with names of places, some of which tell their own tale as belonging to the regions of cloud and mist, while others are indubitably names of places known to us in history. But beyond this they make certain statements about places, which manifestly hold good at the present day. Tiryns and Mykênæ still exist, and their huge walls attest the past greatness of their rulers. When, therefore, the poems speak of these places as powerful cities, they state what is historically true; but we learn the fact not from the poems, but from the actual remains of these towns, whose greatness precedes the dawn of contemporary history. Hence, when the poet tells us that the name of the prince who ruled at Mykênæ was Agamemnon, he may be stating what is not less historically true than his statement that Tiryns had great walls; but so far as the *Iliad* is concerned, Agamemnon remains to us a mere name, while of the events of his life, or of the fortunes of his companions, we know absolutely nothing. They may have fought at Troy; but as we cannot deny the possibility of this fact, so neither can we affirm its reality. That some powerful chiefs must have ruled in Mykênæ, we know; that the name of one of these chiefs was Agamemnon, we can neither maintain nor deny; that he may have done some of the things attributed to him is at once within the limits of possibility and beyond the limits of human knowledge, in the absence of contemporary historical testimony. But it is quite certain that much of what is told of him and his allies could never have taken place; and a comparison of Greek and Hindu myths seems to force on us the conclusion that many, if not most, of the names of the Achæan chieftains are derived from a source common to the Homeric poems and the Vedic hymns. The coincidence of Argynnis and Arjunî, of Brisêis and Vrisaya, of Paris and Pani, of Helen and Saramâ, of Ixion and Akshivan, of Achilleus and Ahalya,

of Daphne and Dahanâ, of Phoroneus and Bhuranyu, with many others, cannot possibly be the result of accident, or of conscious borrowing on the part of the Homeric poets from poets who dwelt between the Ganges and the Indus.

The conclusion is, that we are not justified in denying that men and women, bearing the names which occur in the Homeric or other poems, may have lived in the places to which they are assigned, and may have done some of the acts ascribed to them, and at the same time that we have no warrant (in the absence of historical testimony) for maintaining that they did so act, or that they ever lived at all.

Silenaceæ. One of the names proposed for the *Caryophyllaceæ*.

Silentiary (Lat. silentiarius, from silentium, *silence*). Among the Romans, the title of office of a class of slaves attached to wealthy houses. In the court of the emperors, there was a body of officers attached to the household styled *silentiaries*. Thence the title came to functionaries of higher authority, and was borne by cabinet secretaries in the so-called Lower Empire, and in the courts of Charlemagne and other western potentates who derived their code of ceremonial from Byzantium. Members of the privy council seem to have been sometimes called by this name under the Plantagenets in England.

Silenus (Gr. Σιληνός). In Greek Mythology, the foster-father and attendant of Bacchus, and likewise leader of the satyrs. He was represented as a robust old man in a state of intoxication, and riding on an ass, with a can in his hand. He was invested with prophetic powers, and hence became the symbol of wisdom hidden beneath a rough exterior.

Silex (Lat.) or **Silica.** This important substance constitutes the characteristic ingredient of a great variety of silicious minerals; among which rock-crystal, quartz, chalcedony, and flint may be considered as silica nearly pure. It also predominates in many of the rocky masses which constitute the crust of our globe, such as granite, the varieties of sandstone, and quartz rock. Although silica has none of the ordinary or more obvious acid properties, yet, as it combines in definite proportion with many salifiable bases, and expels carbonic acid when fused with the carbonated alkalies, it is termed *silicic acid*, and its various compounds have been denominated *silicates*. When pure and colourless rock-crystal is heated red hot, and quenched in water, it becomes opaque and friable; and if in this state it be reduced to powder, it presents one form of pure silica. If in this state (in which it is perfectly insoluble in water) it be fused with three parts of carbonate of potash, it forms a glass which is soluble in water, and from this solution (formerly called *liquor of flints*) the concentrated acids throw down the silica in the form of a *gelatinous hydrate*; but if the solution be diluted, and the acid gradually added, the alkali may be neutralised without deposition of the silica; when, however, the solution is evaporated to dryness, the silica remains as insoluble as before. This solubility of hydrated or gelatinous silica, which, when dry, is perfectly insoluble, may serve to explain the occurence of silica in water, and its deposition in chalcedonic incrustations. But silica presents another remarkable character; i.e. that if we reverse the above proportions, and fuse together a mixture of one part of carbonate of potash and three of powdered rock-crystal or calcined flint, we then obtain a transparent and fusible compound, nearly insoluble in water, namely *glass*.

Plate glass and *window glass*, or, as it is commonly called, *crown glass*, are silicates of soda and lime; and *flint glass*, of which our common glass utensils are made, is a silicate of potash and lead. [GLASS.]

Silica, in its ordinary or *anhydrous* state, is insoluble in all acids except the *hydrofluoric*, which immediately acts upon it, and forms a gaseous compound, the *terfluoride of silicon*. Silica was long considered as an elementary form of matter; but Sir H. Davy found that when the vapour of potassium was brought into contact with pure silica heated to whiteness, silicate of potassa was formed, and a dark-coloured matter separated, which was afterwards found to be the base of silica, and to which the terms *silicium* and *silicon* have been applied. [SILICON.]

Silhouette (Fr.). In the Fine Arts, a name given to the representation of an object filled in of a black colour, and in which the inner parts are sometimes indicated by lines of a lighter colour, and shadows or extreme depths by the aid of a heightening of gum or other shining medium. This sort of drawing derives its name from its inventor, Étienne de Silhouette, the French minister of finance in 1759. Representations of this sort may be well enough taken from the shadow of a person thrown on a piece of paper placed against a flat surface or wall. The likeness may be still better taken, if on a reduced scale, by means of the instrument called a PANTAGRAPH.

The invention of what is called a *silhouette* is, however, ascribed to a remote period, being said to have been the method by which the daughter of Dibutades, a Greek potter at Corinth, drew the outline of the shadow of her lover's profile cast by her lamp on a wall; and has been placed at the time of the renewal of the Olympic games, shortly before the expulsion of the Bacchiads from Corinth, about 776 B.C. The father, it is said, cut out the plaster within the outline, took an impression from the space in clay and baked the squeeze with the rest of his pottery. The legend states that this original specimen of the plastic art was still preserved at Corinth when the city was sacked by Mummius 146 B.C. The Etruscan vases furnish to an amazing extent, and in boundless variety, some of the most beautifully drawn and elegant silhouettes that have ever been executed. [PAINTING.]

Silicates (Lat. silex, *a flint*). Compounds of silica (silicic acid) with certain bases; thus we have silicates of lime, magnesia, oxide of iron, &c., amongst minerals; and silicate of *lead* is an important ingredient in flint glass.

Silicificse. Substances petrified or mineralised by silica.

Silicious Sinter. A name given to the light cellular Quartz or opaline silica, which is deposited by the waters of hot springs, such as those of the Geysers in Iceland.

Silicite (Lat. silex, *flint*). The name given by Thomson to a yellowish-white Labradorite from Antrim in Ireland.

Silicon, Silicium. The peculiar non-metallic element which in combination with oxygen constitutes silica. Assuming silica to be a compound of 2 atoms of silicon and 4 of oxygen (Si_2O_4), silicon will be represented by the equivalent 14, and silica, consisting of 28 silicon and 32 oxygen, by 60. Silicon is obtained by the action of potassium or sodium on chloride of silicon or on silico-fluoride of potassium, at high temperatures, and exists in two conditions, amorphous and crystalline. Amorphous silicon is a brown powder, insoluble in and heavier than water, not acted on by sulphuric or nitric acids, but soluble in hydrofluoric acid and in caustic potash; when heated in oxygen it burns into silica. The preparation and properties of silicon have been described by Caron and Deville. (*Ann. de Chim. et Phys.* lxvii. 3me sér.) Like carbon, silicon occurs in the amorphous, graphitoidal, and crystalline forms. It also forms compounds with hydrogen, bromine, fluorine, and sulphur.

Silicula (Lat. dim. of siliqua, *a pod*). In Botany, a fruit exactly similar to that called a siliqua, except that it is shorter, and contains fewer seeds. It is never more than four times as long as broad, and usually much shorter.

Siliqua (Lat.). In Botany, a one or two-celled, many-seeded, linear fruit, dehiscent by two valves separating from a replum. The seeds are attached to two placentæ adhering to the replum, and opposite to the lobes of the stigma.

Silk (A.-Sax. seolc). A fine glossy thread or filament spun by various species of caterpillars or larvæ of the *Phalæna* genus. Of these, the *Phalæna atlas* produces the greatest quantity; but the *Phalæna bombyx* is that which is commonly employed for this purpose in Europe. The silkworm in its caterpillar state, which may be considered as the first stage of its existence, after acquiring its full growth (about three inches in length), proceeds to enclose itself in an oval-shaped ball, or cocoon, which is formed by an exceedingly slender and long filament of fine yellow silk, emitted from the stomach of the insect preparatory to its assuming the shape of the chrysalis or moth. In this latter stage, after emancipating itself from its silken prison, it seeks its mate, which has undergone a similar transformation; and in two or three days afterwards, the female having deposited her eggs (from 300 to 500 in number), both insects terminate their existence.

Many insects, however, besides the genus *Phalæna*, supply silk. Of these, one of the most important is the Ailanthus silkworm, the introduction of which into England has been strongly recommended. Some kinds of spiders also produce silk, but not in such quantities or in such a shape as to have any economical significance.

Raw silk is produced by the operation of winding off, at the same time, several of the balls or cocoons (which are immersed in hot water, to soften the natural gum on the filament) on a common reel, thereby forming one smooth even thread. When the skein is dry, it is taken from the reel and made up into hanks; but before it is fit for weaving, and in order to enable it to undergo the process of dyeing, without furring up or separating the fibres, it is converted into one of three forms—viz. *singles*, *tram*, or *organsine*.

Singles (a collective noun) is formed of *one* of the reeled threads, being twisted, in order to give it strength and firmness.

Tram is formed of two or more threads twisted together. In this state it is commonly used in weaving, as the *shoot* or *weft*.

Thrown silk is formed of two, three, or more singles, according to the substance required, being twisted together in a contrary direction to that in which the singles of which it is composed are twisted. This process is termed *organsining*; and the silk so twisted, *organsine*. The art of throwing was originally confined to Italy, where it was kept a secret for a long period. Stowe says it was known in this country since the 5th of Queen Elizabeth, 'when it was gained from the strangers;' and in that year (1562), the silk throwsters of the metropolis were united into a fellowship. They were incorporated in the year 1629; but the art continued to be very imperfect in England until 1719. [Post.]

1. *Historical Sketch of the Manufacture.*—The art of rearing silkworms, of unravelling the threads spun by them, and manufacturing the latter into articles of dress and ornament, seems to have been first practised by the Chinese. Virgil is the earliest of the Roman writers who has been supposed to allude to the production of silk in China, and the terms employed by him show how little was then known at Rome as to the real nature of the article:—

> Velleraque ut foliis depectant tenuia Seres.
>
> *Georg.* book ii. lin. 121.

But it may be doubted whether Virgil, in this line, refers to cotton rather than silk. Pliny, however, has distinctly described the formation of silk by the *bombyx*. (*Hist. Nat.* lib. xi. c. 17.) It is uncertain when it first began to be introduced at Rome: but it was most probably in the age of Pompey and Julius Cæsar, the latter of whom displayed a profusion of silks in some of the magnificent theatrical spectacles with which he sought at once to conciliate and amuse the people. Owing principally, no doubt, to the great distance of China from Rome, and to the difficulties in the

way of the intercourse with that country which was carried on by land in caravans whose route lay through the Persian empire, and partly, perhaps, to the high price of silk in China, its cost, when it arrived at Rome, was very great; so much so, that a given weight of silk was sometimes sold for an equal weight of gold! At first it was used only by a few ladies eminent for their rank and opulence. In the beginning of the reign of Tiberius, a law was passed—*ne vestis serica viros fœdaret*—that no man should disgrace himself by wearing a silken garment. (Tacit. *Annal.* lib. ii. c. 33.) But the profligate Heliogabalus despised this law, and was the first of the Roman emperors who wore a dress composed wholly of silk (*holosericum*). The example once set, the custom of wearing silk soon became general among the wealthy citizens of Rome, and throughout the provinces. According as the demand for the article increased, efforts were made to import larger quantities; and the price seems to have progressively declined from the reign of Aurelian. That this must have been the case, is obvious from the statement of Ammianus Marcellinus, that silk was, in his time (anno 370), very generally worn, even by the lowest classes. (Lib. xviii. c. 6.)

China continued to draw considerable sums from the Roman empire in return for silk, now become indispensable to the Western world, till the sixth century. About the year 550, two Persian monks, who had long resided in China, and made themselves acquainted with the mode of rearing the silkworm, encouraged by the gifts and promises of Justinian, succeeded in carrying the eggs of the insect to Constantinople. Under their direction they were hatched and fed; they lived and laboured in a foreign climate; a sufficient number of butterflies were saved to propagate the race, and mulberry-trees were planted to afford nourishment to the rising generations. A new and important branch of industry was thus established in Europe. Experience and reflection gradually corrected the errors of a new attempt; and the Sogdoite ambassadors acknowledged, in the succeeding reign, that the Romans were not inferior to the natives of China in the education of the insects, and the manufacture of silk. (Gibbon, *Decline and Fall*, vol. vii. p. 99.)

Greece, particularly the Peloponnesus, was early distinguished by the rearing of silkworms, and by the skill and success with which the inhabitants of Thebes, Corinth, and Argos carried on the manufacture. Until the twelfth century, Greece continued to be the only European country in which these arts were practised; but the forces of Roger, king of Sicily, having, in 1147, sacked Corinth, Athens, and Thebes, carried off large numbers of the inhabitants to Palermo, who introduced the culture of the worm and the manufacture of silk into Sicily. From this island the art spread into Italy; and Venice, Milan, Florence, Lucca, &c., were soon after distinguished for their success in raising silkworms, and for the extent and beauty of their manufactures of silk. (Gibbon, vol. x. p. 110; *Biographie Universelle*, art. 'Roger II.')

The manufacture of silk appears to have been introduced into Spain at a very early period by the Moors, particularly in Murcia, Cordova, and Granada. The last town, indeed, possessed a flourishing silk trade when it was taken by Ferdinand in the fifteenth century. The French having been supplied with workmen from Milan, commenced, in 1521, the silk manufacture; but it was not till 1564 that they began successfully to produce the silk itself, when Traucat, a working gardener at Nismes, formed the first nursery of white mulberry-trees, and with such success that in a few years he was enabled to propagate them over many of the southern provinces of France. Prior to this time, some French noblemen, on their return from the conquest of Naples, had introduced a few silkworms with the mulberry into Dauphiny; but the business had not prospered in their hands. The mulberry plantations were greatly encouraged by Henry IV.; and since then they have been the source of most beneficial employment to the French.

James I. was most solicitous to introduce the breeding of silkworms into England, and in a speech from the throne he earnestly recommended his subjects to plant mulberry-trees; but he totally failed in the project. This country does not seem to be well adapted to this species of husbandry, on account of the great prevalence of blighting east winds during the months of April and May, when the worms require a plentiful supply of mulberry-leaves. The manufacture of silk goods, however, made great progress during that king's peaceful reign. In 1629 it had become so considerable in London, that the silk throwsters of the city and suburbs were formed into a public corporation. So early as 1661 they employed 40,000 persons. The revocation of the edict of Nantes, in 1685, contributed in a remarkable manner to the increase of the English silk trade, by the influx of a large colony of skilful French weavers who settled in Spitalfields. The great silk-throwing mill mounted at Derby, in 1719, also served to promote the extension of this branch of manufacture; for soon afterwards, in the year 1730, the English silk goods bore a higher price in Italy than those made by the Italians, according to the testimony of Keysler. It would be impossible, within our limits, to give an account of the gradual progress of the silk manufacture from that period down to the present time. Upon this subject, the reader will find ample details in the *Commercial Dictionary*; meantime we may remark, that a great revolution was effected in the manufacture in 1825. Before that epoch the legislative enactments with respect to it were the most contradictory and impolitic that can well be imagined. The importation of foreign silks was prohibited under the severest penalties; but the advantage which this prohibition was believed, though most erroneously, to confer on the manufacturer,

would, under any circumstances, have been more than neutralised by the imposition of oppressive duties on the raw material. This vicious system was productive of a twofold mischief; for, by teaching the manufacturers to depend on custom-house regulations for protection against foreign competition, it made them indifferent about new discoveries and inventions, while, owing to the exorbitant duties on the raw material, and the want of improvement, the price of silks was maintained so high as to restrict the demand for them within comparatively narrow limits. In 1825, however, a new and more reasonable order of things was introduced. The duties on the raw material were greatly lowered; and at the same time foreign silk goods were allowed to be imported on payment of a duty of 30 per cent. ad valorem. This new system was vehemently opposed at its outset, and it was confidently predicted that it would occasion the ruin of the manufacture; but the result has shown the soundness of the principles on which it was bottomed. The manufacturers were now, for the first time, compelled to call all the resources of science and ingenuity to their aid; and the result has been that the manufacture has been more improved during the last thirty-five years than it had been in the whole previous century, and that it has continued progressively to increase. These duties were again modified by the Act 9 & 10 Vict. c. 23, by which foreign manufactured silks were charged at 15 per cent. ad valorem, or at an equivalent sum charged by weight. At the same time the duties on raw and thrown silk were repealed. In 1859, all duties on silk manufactures were abolished.

The total quantity of raw silk imported for home consumption in 1865 was nearly 8,000,000 lbs. But the annual importations vary exceedingly. Thus the quantity was more than 12,000,000lbs. in 1857, more than 10,000,000 lbs. in 1862; but only 5,655,401lbs. in 1864. The import of foreign manufactured silk has increased from 300,000lbs. the maximum, before the duty was repealed, to nearly 2,000,000lbs. in the year 1865. The price of the raw material has, however, undergone a considerable increase, the silk, raw and manufactured, imported into this country having been entered in 1865 at more than 17,600,000*l.* The number of persons engaged in the silk manufacture does not probably exceed 250,000. According to Mr. Fortune, the supply of silk derivable from China is all but inexhaustible, the increased demand for Chinese produce having hardly had any effect on the price of the raw material in the silk districts. The same, too, may be said of Japan; and if the attempts to naturalise various silk-producing insects, and especially the Ailanthus, in England, succeed, silken fabrics of various fineness and brilliancy will become plentiful and cheap.

Silk-cotton Tree. [BOMBAX.]

Silkworm. The larvæ of many species of Lepidopterous insects enclose themselves in a filamentary secretion called *silk*, but the name *silkworm* is given par excellence to that of the mulberry moth (*Bombyx mori*, Linn.), on account of the quality and abundance of the material of the case or *cocoon* in which the final metamorphosis takes place. The silkworm is a modified or domesticated variety of a species aboriginal, it would seem, to China.

Silk is a secretion of a pair of tubes called *sericteria*, which terminate in a prominent pore or *spinnaret* on the under lip of the caterpillar. Before their termination they receive the secretion of a smaller gland, which serves to glue together the two fine filaments from the sericteria: the apparently single thread being in reality double, and its quality being affected by the equality, or otherwise, of the secreting power of the two sericteria. When full-grown, the silkworm begins to spin, in some convenient spot affording points of attachment for the first-formed thread, which is drawn from one part to the other until the body of the larva becomes loosely enclosed by the thread. The work is then continued from one thread to another, the silkworm moving its head, and spinning, in a zigzag way, in all directions within reach, and shifting the body only to cover the part which was beneath it. The silken case so formed is called the *cocoon*. During the period of spinning the cocoon, which usually takes five days for its completion, the silkworm decreases in size and length; then casts its skin, becomes torpid, and assumes the form of the chrysalis. The main object of the silkworm breeder is to obtain cocoons of a large size, composed of a long, strong, very fine, even and lustrous thread. Different varieties of silkworm have thus been established, such as the *Sina*, *Syrie*, and *Novi* races in France.

Besides the silk from the *Bombyx mori*, stronger and coarser kinds are obtained, as in India, from the tussur moth (*Saturnia mylitta*), which feeds on the leaves of the *Terminalia catappa* and *Zizyphus jujuba*. The cloth woven from this silk is called *tussur cloth*, and is made chiefly at Midnapore. The *moonga silk* is from the *Bombyx saturnia*, which feeds upon the same trees as the tussur moth. The *Phalæna* (*Attacus*) *cynthia* produces the *eri* silk, woven into cloth at Assam: the larvæ feed on various leaves, but prefer those of the castor-oil plant (*Ricinus communis*). They have lately received attention under the name *Ailanthus silkworm*.

As in other instances of domesticated varieties, the silkworm is subject to diseases, of which that named the *muscardine* is the most disastrous to the sericiculturist. It has received great attention in Italy, from Dr. Bassi of Lodi, and in France from Andoin, Guerin-Méneville, Quatrefages, and others.

Sill (Sax. syl). In Architecture, the horizontal piece at the bottom of a framed case, such as that of a door or window. This word is also used to denote the bottom piece of a quarter partition. *Ground sills* are those timbers on the ground on which are placed the posts and superstructure of a timber building.

Sill of an Embrasure. In Fortification, the inner edge of the bottom or sole of an embrasure.

Sillimanite. An anhydrous silicate of alumina, found in a vein of gneiss at Chester near Saybrook, in Connecticut. It is of a dark grey colour passing into clove-brown, and either occurs in slender prisms, which are flattened and striated, or fibrous, columnar, or compact massive. Named after Professor Silliman.

Sillon (Fr.). In Fortification, a work raised in a ditch to defend it if too wide. It may be of any form, but must be lower than the works of the place, and higher than the covered way.

Silphium (Gr. σίλφιον). A genus of large-growing *Compositæ*, of which the most interesting species is the Compass-plant, *S. laciniatum*, the leaves of which *are said* to present their faces uniformly north and south, a statement which needs confirmation. The plant is also known as Pilot-weed, Polar-plant, Rosin-weed, and Turpentine-weed—the latter named from the abundant resin exuded by its stems, which grow to a height of three to six feet, as well as by the leaves, which are deeply pinnatifid. The tuberous roots of *S. læve*, a plant with smooth dock-like leaves, are eaten by the natives of the Columbia River valley. *S. perfoliatum* gets the name of Cup-plant, because the winged stalks of its opposite leaves are united together so as to form a cup with the stem in its centre.

Silphium is also the name given to a gum-resin supposed by some to be obtained from *Thapsia Silphion*, and by others from *Prangos pabularia*.

Silt. The name given to the sand, clay, and earth which accumulate in running waters.

Silurian. The name given by Sir Roderick Murchison to a series of rocks forming the upper subdivision of the sedimentary strata found below the old red sandstone, and formerly designated the *greywacke series*. These strata are well developed in that part of England and Wales formerly included in the ancient British kingdom of the *Silures*. [GEOLOGY.]

Siluridans (Lat. silurus; Gr. σίλουρος, *a sheath-fish*). The name of the family of fishes of which the genus *Silurus* is the type, and which includes the electric silurus (*Malapterurus electricus*). They are chiefly distinguished by the want of true scales, having merely a naked skin, or large osseous plates. A strong osseous spine forms the first ray of the dorsal and pectoral fins, except in the genus *Malapterurus*.

Silvanite. [SYLVANITE.]

Silvanus. A rural Italian deity; so called from Lat. silva, *a wood*. He also presided over boundaries.

Silvas (Span.; Lat. silva, *a wood*). A tract covered with forest vegetation, occupying at least a million of square miles in the tropical part of South America. A fifth part of this vast area is annually subject to inundation, and the exuberance of animal and vegetable life resulting from such conditions renders the whole district almost hopelessly unapproachable by civilised man. This tract is chiefly on the course of the Amazon, and the group of rivers connected with it.

Silver (Ger. silber). This metal, the *Luna* or *Diana* of the alchemists (☽), represented by the symbol Ag (argentum), and by the equivalent 108, is found *native*, and in a variety of combinations, the most common of which is the *sulphide*. *Native Silver* occurs massive; arborescent, capillary, and, sometimes, crystallised. It is seldom pure, but contains other metals, which affect its colour and ductility.

Silver is not unfrequently obtained in considerable quantities from *argentiferous sulphide of lead*, which is reduced in the usual way, the argentiferous lead being then fused in a shallow dish, placed in a reverberatory furnace, with a current of air constantly passing over its surface; in this way the lead is converted into oxide or *litharge*, and the silver is left in the metallic state.

The sulphides of silver are reduced by *amalgamation*. The ore, when washed and ground, is mixed with a portion of common salt, and roasted. During this operation arsenic and antimony are expelled, the copper and the iron are converted into oxides, chlorides, and sulphates, and sulphate of soda and chloride of silver are formed. The pulverised product is agitated with mercury, water, and filings or fragments of iron; in this operation the chloride of silver is decomposed, chloride of iron is formed which is washed away, and the silver and mercury combine into an amalgam, from which the excess of mercury is first squeezed out through leather bags, and the remainder driven off by distillation.

Pure Silver may be procured by dissolving standard silver in nitric acid, diluted with an equal measure of water. Immerse a plate of clean copper in the filtered solution, which occasions a precipitate of metallic silver; collect it upon a filter; wash it with a weak solution of ammonia, and then with water, and fuse it into a button.

Silver is of a more pure white than any other metal: it has considerable brilliancy, and takes a high polish. Its specific gravity varies between 10·4 and 10·6. It is so malleable and ductile, that it may be extended into leaves not exceeding a ten-thousandth of an inch in thickness, and drawn into wire infinitely finer than a human hair. Silver melts at a bright red heat, estimated at 1873° of Fahrenheit's scale, and when in fusion appears extremely brilliant. It resists the action of air at high temperatures for a long time, and does not oxidise; the *tarnish* of silver is occasioned by sulphuretted hydrogen. Pure water has no effect upon the metal; but if the water contains organic matter, it is sometimes slightly blackened. In the Voltaic arc it burns with a fine green light, and throws off abundant fumes. Exposed to an intense white-heat in the air, it evaporates, but in close vessels it is not sensibly volatile. If suddenly cooled, it crystallises during congelation, often shooting out like a cauliflower, and *spirting* particles of the metal out of the

crucible. This arises from the escape of oxygen, which the metal absorbs and retains whilst fluid, but suddenly gives off when it solidifies: this curious property of absorbing oxygen without combining with it, is prevented by the presence of a small quantity of copper.

There are three oxides of silver—a suboxide, Ag_2O; a protoxide, AgO; and a binoxide, AgO_2. But the protoxide only forms permanent and definite saline combinations. It is obtained by adding a dilute solution of potash to a solution of nitrate of silver. It is of a dark olive colour, and when heated to dull redness is reduced to the metallic state. It imparts a yellow colour to glass, and is employed in enamel and porcelain painting. Berthollet's *fulminating silver* is formed by the action of ammonia on this oxide. The best process for preparing it is to pour a small quantity of strong aqueous ammonia upon the oxide; a portion is dissolved, and a black powder remains, which is the detonating compound. It explodes with tremendous violence when rubbed or heated; nitrogen and water are evolved, and the silver is reduced. It is probably a nitride of silver, $=Ag_3N$. Fulminate of silver, which is the compound usually known as FULMINATING SILVER, has been already noticed.

When silver leaf is acted upon by gaseous chlorine in a humid state, it is gradually converted into a white chloride of silver; but this compound is usually procured by adding a solution of common salt to a solution of nitrate of silver. It falls in the form of a white curdy precipitate, which, by exposure to light, becomes violet-coloured, brown, and ultimately black, a property which has led to its employment in photography. Chloride of silver is so insoluble in water, that the minutest portion of any chloride in aqueous solution may be detected by it. It is insoluble in nitric and in cold sulphuric acid, but is abundantly soluble in solutions of ammonia, cyanide of potassium, and the alkaline hyposulphites.

Iodide and *Bromide* of silver are yellowish insoluble compounds, both of which have been found *native* in Mexico. They are principally important in reference to photography.

Nitric acid diluted with three parts of water, is the readiest solvent of silver: if the silver contains copper, the solution is bluish; or if gold, that metal remains undissolved in the form of a black powder. The solution of nitrate of silver is caustic, and tinges animal substances at first of a yellow $=A$, becoming, by exposure to light, purple or black. On evaporation, the solution yields anhydrous tabular crystals of a bitter metallic taste, which fuse when heated, and if cast into small cylinders, form the *lunar caustic* of pharmacy.

When some of the solutions of silver are reduced by certain essential oils, or by grape-sugar, a brilliant film of the metal may be so thrown down upon glass as to furnish a substitute for the amalgam of tin usually employed for mirrors. This coating is not to be depended upon for durability, but it has the advantage of being applicable to curved surfaces and the interior of spherical vessels.

Nitrate of silver is employed for writing upon linen, under the name of *indelible* or *marking ink*: and it is an ingredient in some of the liquids sold for changing the colour of hair. When taken internally, a discoloration of the skin often ensues, so that the surface of the body, and especially the parts exposed to light, acquire a leaden-grey colour.

Solution of nitrate of silver is a valuable test of the presence of chlorine, hydrochloric acid, and the soluble chlorides, with which it forms a white cloud when very dilute, but a flaky precipitate when more concentrated; the precipitate is soluble in ammonia, but insoluble in nitric acid.

Silver is dissolved by boiling sulphuric acid, and the resulting *sulphate of silver* is a difficultly soluble white salt. Upon the large scale, small portions of gold are separated from large quantities of silver, by heating the finely granulated alloy in sulphuric acid: the gold remains in the form of a black powder, and the sulphate of silver may be decomposed by the action of metallic copper, which precipitates metallic silver, and forms sulphate of copper.

Some of the *cyanides* of silver are used in the process of electro-plating.

Of the *alloys* of silver, the most important is that with *copper*; it constitutes plate and coin. By the addition of a small proportion of copper to silver, the metal is rendered harder and more sonorous, while its colour is scarcely impaired. When the two metals are in equal weights the compound is white: the maximum of hardness is obtained when the copper amounts to one-fifth of the silver. The *standard silver* of this country is composed of 92·5 silver + 7·5 copper; that of France of 90 silver + 10 copper; and in that of Prussia the alloy amounts to 25 per cent. The specific gravity of British standard silver is 10·3. The silver coins of the ancients, and many Oriental silver coins, are nearly pure; they only contain traces of copper and of gold. When silver alloyed by copper, such as standard silver, is exposed to a red heat in the air, it becomes black from the formation of a superficial film of oxide of copper; this may be removed by immersion in hot diluted sulphuric acid, and a film of pure silver then remains, of a beautiful whiteness; this is called *blanched*, *dead*, or *frosted silver*. The blanks for coin are treated in this way before they are struck, whence the whiteness of new coin, and the darker appearance of the projecting portions occasioned by wear, in consequence of the alloy showing itself beneath the pure surface; articles of plate are often deadened, *matted*, or *frosted* by boiling in bisulphate of potash (*sal enixum*), which acts in the same way as dilute sulphuric acid. *Lead* and silver form a very brittle dull-coloured alloy, from which the lead is easily separated by cupellation. When fused lead containing silver is suffered to cool slowly, the lead, which first concretes, forms granular crystals, and is nearly pure, while almost the

whole of the silver is contained in the liquid portion; in this way the separation of the two metals may to a certain extent be effected, especially upon the large scale. Silver amalgamates easily with *mercury*: when red-hot silver is thrown into heated mercury it dissolves, and when 8 parts of mercury and 1 of silver are thus combined, a granular crystalline soft amalgam is obtained. This amalgam is sometimes employed for *plating*; it is applied to the surface of copper, and the mercury being evaporated by heat, the remaining silver is burnished. The better kind of plating, however, is performed by the application of a plate of silver to the surface of the copper, which is afterwards extended by rolling. A mixture of chloride of silver, chalk, and pearlash, is employed for silvering brass: the metal is rendered very clean, and the above mixture, moistened with water, rubbed upon its surface. Plating by metallic precipitation from ammonio-chloride of silver is also frequently resorted to, but *electro-plating* with cyanide of silver now supersedes the other methods.

Assay of Silver.—The analysis of alloyed silver is in continual practice by refiners and assayers. It may be performed in the humid way by dissolving the alloy in nitric acid, precipitating with hydrochloric acid or chloride of sodium, and either reducing the chloride, or estimating the quantity of silver which it contains; every 100 parts of the carefully dried chloride indicating 75·33 of silver.

But a modification of this method is now generally resorted to, especially applicable in cases where the quality of the alloy is approximately known: it depends upon the precipitation of the silver by a *standard solution of common salt*, each 1,000 grains of which contain a sufficient quantity of salt to precipitate 10 grains of silver; so that, supposing the silver and the salt to be pure, 10 grains of silver dissolved in nitric acid, would be entirely precipitated by 1,000 grains of the standard solution. This process of humid assaying was introduced into the French Mint by Gay-Lussac, who has described it in detail. A description of this method by Mulder will also be found in the *Chemical News*, 1861, vol. ii. pp. 137-204.

Assayers generally determine the value of silver bars by the process of *cupellation*. Of the useful metals, three resist the action of air at high temperatures—namely, silver, gold, and platinum; the others, under the same circumstances, become oxidised; it might, therefore, be supposed, that alloys of the first three metals would suffer decomposition by mere exposure to heat and air, and that the oxidisable metal would burn into oxide. This, however, is not the case; for if the proportion of the latter be small, it is protected by the former; or, in other cases, a film of infusible oxide coats the fused globule, and prevents the further action of the air. These difficulties are overcome by adding to the alloy some easily oxidisable metal, the oxide of which is *fusible*. Lead is usually selected for this purpose. Supposing, therefore, that an *alloy of silver and copper* is to be *assayed* or analysed by *cupellation*, the following is the mode of proceeding: A clean piece of the metal (about 20 grains) is laminated, and accurately weighed. It is then wrapped in the requisite quantity of *pure* sheet lead, apportioned by weight to the *quality* of the alloy, and placed upon a small *cupel*, or porous shallow crucible, made of bone-earth. The whole is then placed within a *muffle*, heated to bright redness; the metals melt, and, by the action of the air which plays over the hot surface, the lead and copper are oxidised, and their fused oxides are absorbed by the cupel, and, if the operation has been skilfully conducted, a button of pure silver ultimately remains, the completion of the process being judged of by the cessation of the oxidation and motion upon the surface of the globule, and by the brilliant appearance assumed by the silver when the oxidation of its alloy ceases. The button of pure silver is then suffered to cool gradually, and its loss of weight will be equivalent to the weight of the alloy which has been separated by oxidation, a certain allowance being made for a small loss of silver, which always occurs, partly by evaporation, and partly by absorption in the cupel.

Silver Black. An earthy form of Silver Glance, of a dark bluish-black colour, found in several Saxon and Hungarian mines.

Silver Glance. A valuable ore of silver; composed of 87·1 per cent. of silver, and 12·9 sulphur. It is of a blackish-grey colour, but acquires a superficial iridescent tarnish on exposure; opaque, with a metallic lustre; flexible but difficultly frangible; malleable and sectile, yielding easily to the knife and cutting like lead. It is found in various cubical forms; also dendritic, stalactitic, and amorphous, in several Cornish mines.

Silver or Glass Speculum. A speculum of glass silvered in the manner described in art. SILVERING, and used in reflecting telescopes instead of a metallic reflector. [TELESCOPE.]

Silver Grain. The glittering plates observed in the wood of many Exogens, and caused by the division of the medullary plates.

Silvering. The art of fixing thin films of silver on various surfaces. Copper may be coated with silver by first amalgamating the latter with mercury, rubbing the compound over the cleaned copper, and then volatilising the mercury by heat. Glass surfaces may be silvered by covering with an alkaline solution of oxide of silver, and then adding a reducing agent such as milk-sugar; this process gives a very brilliant surface. Ordinary mirrors, or *looking-glasses* as they are generally termed, owe their reflecting powers to a surface of tin and mercury, and not to pure silver; hence the process may, in this case, be called *quicksilvering* rather than silvering, though the latter name is generally adopted. Quicksilvering consists in placing on a flat table a sheet of tin-foil, adding some mercury, and rubbing

it gently over the tin till amalgamation is effected, then sliding on the sheet of glass, and applying considerable pressure for two or three days; excess of quicksilver is thereby removed, and the residual amalgam adheres firmly to the glass.

Silvic Acid. A name applied to that portion of common resin or colophony which is most readily soluble in cold alcohol. Its combinations with salifiable bases have been termed *silvates*. It is crystallisable, and its alcoholic solution reddens litmus.

Silybum (Gr. σίλυβος, or σίλλυβος). A genus of thistle-like *Compositæ*, the most familiar of which is *S. Marianum*, the Milk Thistle, which grows to the height of three or four feet or more, with large spreading wavy spinous leaves, of which those next the root are pinnatifid, and variegated with green and milk-white. The specific name *Marianum* was given to this plant to preserve the legend that the white stain on the leaves was caused by the falling of a drop of the Virgin Mary's milk. It was formerly cultivated, the young leaves being used as a spring salad, the root boiled as a pot-herb, and the heads treated like the heads of the artichoke. It grows wild in waste places in many parts of England, and still retains its place in old-fashioned gardens.

Simaba. The native Guiana name of a plant representing a genus of *Simarubaceæ*, consisting of trees and shrubs, having the leaves alternate, and either simple or ternate or pinnate, and the flowers axillary.

S. Cedron, a small tree of New Granada, which bears a fruit about the size of a swan's egg, containing only one seed, possesses valuable remedial properties. The kernel of this seed, the Cedron of commerce, which looks like a blanched almond but is larger, appears to have been known to the inhabitants from time immemorial as a remedy for the bites of serpents. Its reputation is probably owing partly to its febrifugal powers in intermittent fever, it being successfully prescribed in that disease by the physicians of New Grenada, a country abounding in forests of quina-trees. The natives universally believe that it will neutralise the poison even of the most dangerous reptiles. On the latter account it is so much valued, that there are scarcely any persons in New Grenada or the adjacent states who have not a piece of this seed, which they always carry with them; and a single seed will sell for four shillings. The active principle on which the medicinal qualities of the Cedron depend has been separated by M. Lecoy, who has named it *cedrine*. Every part of the plant, but especially the seed, is, owing to its presence, intensely bitter.

Simaruba (its name in Guiana). A genus of *Simarubaceæ*, consisting of tropical American trees, one of which, *S. amara*, a native of the West Indies and Guiana, yields the drug known as Simaruba-bark, which is, strictly speaking, the rind of the root. It is employed as a bitter tonic in diarrhœa and dysentery, as well as in various forms of indigestion. In large doses it is said to act as an emetic purgative and diaphoretic. *S. versicolor*, a Brazilian species, has similar properties. The fruits and bark are used as anthelmintics, and an infusion of the latter is employed in cases of snake-bite. The plant is intensely bitter, and its powdered bark has been employed to kill vermin.

Simarubaceæ (Simaruba, one of the genera). A natural order of arborescent or shrubby Hypogynous Exogens, inhabiting the tropics, and belonging to the Rutal alliance. The species are exceedingly bitter. The wood of QUASSIA is well known. The *Simaruba versicolor* of St. Hilaire, called *Paraiba* in Brazil, possesses such excessive bitterness that no insects will attack it; and *Picræna excelsa*, another species of the order, is employed in medicine for the same property. The order is known by the alternate stipulate leaves, the few-seeded apocarpous fruit, the dry inconspicuous torus, and the exalbuminous seeds. The species are nearly all natives of tropical America, India, or Africa.

Simia (Lat. *an ape*, from simus, Gr. σιμός, *flat-nosed*). The generic name applied by Linnæus to all the Quadrumanous Mammals, except the Lemurs. The Linnæan *Simiæ* are divided into numerous subgenera, to none of which the name Simia is now applied, except by some modern naturalists to the orang-utan (*Simia satyrus*) and the mias Kassar (*S. morio*).

Similar (Lat. similis, *like*). In Geometry, similar figures are those which have the same *shape*. More accurately defined, similar rectilineal figures or polygons are such as have their angles respectively equal, and the sides about the equal angles proportional. Of these two conditions, triangles alone necessarily satisfy the one when they satisfy the other. Similar polyhedrons are those which are contained by the same number of similar faces, similarly situated with respect to each other, and having the same mutual inclinations. Generally, two figures are said to be similar when one can be moved so that like directed and co-initial radii vectores of the two are proportional. In this position the common origin of the radii vectores is termed a *centre of similitude*. Two similar figures can be brought into this position in innumerable ways, each way corresponding to a different centre of similitude, and when this can be effected by the mere *translation* of one figure without rotation, the figures are said to be *similar* and *similarly situated*. All circles are similar, as are also all spheres. The latter, too, are similarly situated, as are also the former, provided they are in the same plane. All ellipses are similar whose principal axes have the same ratio, and they are similarly situated when these axes are parallel. All parabolas are similar. The equations of two curves or two surfaces being given, it is easy, from the above definition, to discover the relations which must exist between their co-

efficients in order that the figures may be similar.

Simile (Lat. *like*). In Rhetoric, the same as COMPARISON.

Similiter (Lat. *in like manner*). In Law, the technical designation of the form by which either party, in pleading, accepted the issue tendered by his opponent. The one having concluded his plea, replication, &c. by *putting himself upon the country*, i. e. praying that the truth of the facts may be enquired of by a jury, the other added the similiter, which was in the form, 'And the said A. B. as to the plea &c. of the defendant (or plaintiff) above pleaded, and whereof he hath put himself upon the country, doth the like.' But this technicality was superseded by the Common Law Procedure Act, 1852. [PLEADING.]

Similitude (Lat. similitudo, from similis). In Geometry, the relation which similar figures bear to each other. The *centre of similitude* of two similar figures is a point such that like or oppositely directed radii vectores from it to the two figures are proportional. [SIMILAR.] In the case of two circles, there are two centres of similitude; one divides the line joining the centres of the circles externally, the other internally, into segments which are proportional to the conterminous radii; the former is called the *external*, and the latter the *internal centre of similitude*. If the circles lie wholly without each other, the centres of similitude are obviously the intersections of common tangents. If A and B be the centres of two circles, and S a centre of similitude, a line drawn through S so as to cut the circles in a, a_1 and b, b_1 respectively, will determine two pairs of parallel radii, say Aa, Bb and Aa_1, Bb_1. In such a case a and b as well as a_1 and b_1 are said to *correspond directly*, whilst a and b_1 as well as a_1 and b *correspond inversely*. Similarly a secant through any two points of one circle corresponds directly to the secant through the directly corresponding points of the other, and inversely to the secant through the inversely corresponding points. This being understood, it can be easily shown that two directly corresponding secants are always parallel, whilst two secants which correspond inversely intersect one another on the radical axis of the two circles. It is easy to see how this property becomes modified when the secants become tangents. The line joining the points of contact of a circle which touches two other circles always passes through a centre of similitude of the latter. The circle whose diameter is the segment between the two centres of similitude is sometimes called the *circle of similitude*. Viewed from any point on this circle, the two original circles appear equally large.

The six centres of similitude of three circles, taken in pairs, lie three by three on four lines, which are called *axes of similitude*. The line upon which the three external centres of similitude are situated, is distinguished as the *external axis of similitude*. In general, eight circles can be drawn to touch three given circles. Taken in pairs, these eight circles have the four axes of similitude for radical axes. The centres of any two circles which form a pair lie on the perpendicular let fall from the radical centre of the three given circles upon one of their axes of similitude. (Salmon's *Conics*, and Mulcahy's *Principles of Modern Geometry*, Dublin 1862.)

Simonians. The name given to the followers of Simon Magus, who is described as pretending to be the great virtue and power of God sent from heaven to earth. Their system was a medley of the philosophy of Plato, the mythological fables of the heathens, and of Christianity. The sum of their doctrines, as enjoined by their founder, was, that from the Divine Being flow various orders of eternal natures, subsisting in the plenitude of the Divine essence; that beyond these are different classes of intelligences, to the lowest of which belongs the human soul; that matter is the most remote production of the emanative power, which, on account of its distance from the fountain of light, possesses sluggish and malignant qualities, which are the cause of evil; that it is the great design of philosophy to deliver the soul from its imprisonment in matter, and that for this purpose God had sent us one of the first *æons* into the world. They believed also in the transmigration of souls, and denied the resurrection of the body.

Simonians, Saint. [SAINT SIMONIANS.]

Simony. In Law, an unlawful contract for the presenting a clergyman to a benefice. When such presentation is made corruptly, for money, gift, or reward, by stat. 31 Eliz. c. 6, such presentations are void, and the crown shall present for that turn; and by 12 Anne st. 2. c. 12, if anyone, for money or profit, procures in his own name the next presentation to any living ecclesiastical, and is presented thereupon, the contract is simoniacal. But the sale of an advowson is not simoniacal, whether the benefice be full or not, unless made with a corrupt view to the next presentation, though if the benefice be not full, the next presentation does not pass by a conveyance of the advowson. The term is derived from Simon Magus, but it is generally remarked that the practices against which our laws are directed bear no precise similarity to the offence ascribed to him in the Acts of the Apostles, and the purchase, *on behalf* of a particular clergyman, of the next presentation to a benefice, is a matter frequently arranged.

Simoom. A hot arid wind which blows in Arabia, Syria, and the adjacent countries, and chiefly about the time of the equinoxes. The simoom, which is identical with the *khamsin* of Syria, and the *samiel* of the Turks, and resembles in many respects the *sirocco* and *sorana* of other countries, derives its qualities from blowing over sandy deserts heated intensely by the sun. Sometimes it blows in squalls, bearing along with it quantities of burning sand and dust. In the desert it is greatly dreaded; and the only chance of safety which the traveller has

is to fall down with his face close to the ground, and to continue as long as possible without drawing breath. It is described by Bruce, Volney, Charind, Malcolm, and other travellers.

Simple Contract Debt. In Law, where the contract on which the debt arises is neither ascertained by matter of record (as by the judgment of a court of law) nor by deed or special instrument (as mortgages, bonds, &c.), but by oral evidence, bill of exchange, promissory note or other writing not under seal.

Simplicimanes (Lat. simplex, *simple*; manus, *a hand*). A name given by Latreille to a tribe of Caraboid beetles, comprehending those in which, in the male, the two anterior tarsi are dilated.

Simplicirostres (Lat. simplex; rostrum, *beak*). The name of the first group of *Natatores*, or swimming birds, in the system of Lilljeborg, including those in which the beak is without laminæ, and in which both parents sit on the eggs, take care of the young and carry food to them: the Penguins, Gulls, and Pelicans are examples of this group.

Simplicity (Lat. simplicitas, from simplex). In the Fine Arts, that quality in works of art through which the elements are arranged in the most natural order, and in which the ideas and images are so presented to us that the principal objects are not eclipsed by the accessories, and the details are in due subordination to the whole. Simplicity is the reverse of excess and exaggeration, and may be properly called a negative quality in art.

Simultaneous Equations. A name given to such equations as are satisfied by a common system of values ascribed to the variables or unknown terms which they involve. When the equations are independent, and equal in number to the number of variables they involve, such a common system of values or *roots* is always possible. All works on algebra explain methods of finding these roots. [ELIMINATION; RESULTANT.]

Simultaneous Differential Equations are such as can be satisfied, simultaneously, by a system of relations between the variables. The latter constitutes the *complete solution* when it involves the requisite number of arbitrary constants. The most important class of such differential equations is that in which as in the problems of physical astronomy, there is but one independent variable (e.g. the time) and the number of equations is equal to the number of dependent variables (e.g. co-ordinates of celestial bodies).

A system of n differential equations of the first order and degree connecting $n+1$ variables $x, x_1, \ldots x_n$ may always be made to assume the symmetrical form

$$\frac{dx}{X} = \frac{dx_1}{X_1} = \frac{dx_2}{X_2} \ldots = \frac{dx_n}{X_n}$$

where X, X_1, &c. are functions of the $n+1$ variables. The important problem of its complete solution has been shown by Lagrange and Jacobi (Crelle's *Journal*, t. ii.) to depend upon that of an ordinary differential equation of the n^{th} order between two of the variables; whence it follows that the complete solution in question consists of n equations connecting the $n+1$ variables with n arbitrary constants.

When X, X_1, X_2, &c., are linear functions of the variables, the above system is susceptible of integration by an elegant and symmetrical method, indeed more generally the complete solution of the system,

$$\frac{dx_1}{X_1+T_1} = \frac{dx_2}{X_2+T_2} = \ldots \frac{dx}{X_n+T_n} = \frac{dt}{T},$$

(where T, T_1 &c. . . . are any functions of the independent variable t, and X_1, X_2, &c. are linear and homogeneous functions of the dependent variables x_1, x_2 &c. . . . x_n) may always be made to depend upon that of a linear differential equation of the first order in two variables, and upon the solution of an algebraic equation of the n^{th} degree.

A system of simultaneous differential equations of an order higher than the first, may always be reduced to a system of the first order, by introducing new variables for each of the differential coefficients in the original system except those whose orders are the highest of their kind. The number of dependent variables, and therefore of equations, in the transformed system will be equal to the sum s of the indices of the several differential coefficients of highest order in the original system. The complete solution, therefore, will consist of s equations involving an equal number of dependent variables and each provided with an arbitrary constant. If from this system the $s-n$ introduced variables be eliminated, there will remain n equations connecting the original $n+1$ variables with s arbitrary constants, which system will constitute the complete solution required.

Simurg. [Roc.]

Sin Offering. In the Old Testament, the sacrifice of propitiation for the sin of the people, enjoined in Lev. iv. and considered different from the trespass offering (ibid. xiv.), thought to be appropriate to special cases of negligence only.

Sinapine. A peculiar organic base extracted from mustard seed (*Sinapis alba*). It is a white crystallisable inodorous substance, of a bitter taste, accompanied by the flavour of mustard. Its formula is $C_{32}H_{23}NO_{10}$.

Sinapis (Gr. σίναπι, *mustard*). A genus of Cruciferous herbs, containing several species of interest, the most important of which are those called Black and White Mustard.

The Black Mustard, *S. nigra*, yields the greater portion of the condiment so generally used in this country under the name of mustard. The plant is indigenous, and is largely cultivated in Yorkshire and Durham. The seeds are of reddish-brown colour, and mixed with those of *S. alba* they are crushed between rollers, and subsequently pounded and sifted twice or oftener. From the residue left on the sieve a

fixed oil is obtained by pressure. The powdered mustard is usually mixed with a considerable quantity of wheaten flour and a small quantity of turmeric powder—admixtures readily detected by the microscope. The chemical ingredients of mustard-seeds are somewhat complex. Among them is a peculiar acid called myronic acid, noticeable as containing a proportion of sulphur, and which, when mixed with water and a peculiar substance called *myrosine* (analogous to albumen), also found in mustard-seeds, yields Volatile Oil of Mustard, which has no separate existence in the seeds, but is formed artificially in the manner just stated. This oil is very acrid, and has been employed as a rubefacient. The fixed oil before mentioned as existing in the seed itself has little or no acridity, and has been used as a purgative and vermifuge.

In modern medicine mustard is most frequently employed in the well-known form of poultice, a safe and most valuable application where a speedy result is desired, but one which if allowed to remain on too long, especially in persons who are not sensitive to pain, may produce ulceration and gangrene. Internally, it is employed as an emetic in narcotic poisoning, &c. As a condiment it is valuable for its stimulant effects, which render it useful in cases of weak digestion, or as an adjunct to fatty and other indigestible articles of food.

The White Mustard, *S. alba*, also indigenous in this country, has seeds larger than those of the Black Mustard, and of a yellow colour externally. Chemically they differ in containing a crystalline substance known as *sulpho-sinapisin*. Moreover, their myrosine yields with water a pungent oil of a different character from the volatile oil of mustard previously mentioned. The seeds have similar properties to those of *S. nigra*. They have been recommended to be swallowed whole as stomachics and laxatives, a process by no means free from danger. The seed-leaves or cotyledons of this plant, together with those of *Lepidium sativum*, form the well-known agreeable salad known as mustard and cress. The facility and speed with which this salad may be grown at all seasons and in all places, together with its wholesome properties, are great advantages.

Various other species are cultivated for their leaves or for the oil derived from the seeds. Among them are, *S. chinensis*, *S. dichotoma*, *S. pekinensis*, *S. ramosa*, and *S. glauca*. The seeds of *S. arvensis*, the Common Charlock, yield a good burning oil, and in France its leaves are used as forage for cattle. The leaves of *S. cernua* are eaten in Japan, while the seeds furnish an oil. *S. juncea* is cultivated for its oil, called in India Soorsa; it is used for burning, and also for rubbing the body in illness. *S. nigra*, which grows some ten or twelve feet high in Palestine, is regarded by some as the Mustard of Scripture, in preference to *Salvadora*.

Sinapism. A mustard poultice.

Sinciput (Lat.). The anterior region of the upper part of the head, from the vertex to the eyes in Mammals, and from the vertex to the base of the beak in birds.

Sine (Lat. sinus). In Trigonometry, the ratio of the perpendicular to the hypothenuse of any right-angled triangle is termed the sine of the angle at the base. [TRIGONOMETRY.]

The *sine of an arc*, by means of which the sine of an angle used to be defined, is the half of the chord of the doubled arc; in other words the perpendicular let fall from one extremity of the arc upon the radius to the other extremity. Ptolemy, in the graphical constructions in the *Analemma*, makes use of the semichords instead of the chords; but the introduction of the sines into trigonometrical calculation was an important improvement, of which the credit appears to be due to the Arabian astronomer Albategnius. (Delambre, *Astronomie du Moyen Age*, p. 12.) The term *sine* has been variously derived; the Arabic name is *gib*, or *dgib*, signifying *a fold*, of which *sinus* is the Latin translation. (Hutton's *Mathematical Tables*.)

Sine Die (Lat. *without day*). In Legal and Parliamentary usage, an adjournment or prorogation *sine die* means without any specified day for resuming the subject or reassembling.

Sine quâ non (Lat. *without which not*). A phrase used to signify any indispensable condition.

Sinecure (Lat. sine curâ, *without care*). In Politics, an office without any duties attached to it. The term is properly ecclesiastical, and applied to a benefice without cure of souls; in which sense it is also still employed.

Singers of Germany. A general title, which may be regarded as including the MINNESINGERS as well as the Meister-singers of Germany. The latter became known in the fourteenth century, and are traced to the institutions of the twelfth century, called *singing schools*, for the promotion of popular music. They differed from the Minnesingers by confining themselves to didactic and moral subjects, and regulated their verse by minute and pedantic laws, without any other idea of excellence than that of conformity to rule. They are said to have originated at Mentz, and were incorporated by Charles IV. in 1378 under the name of Meistergenossenschaft. (Hallam, *Literary History*, part. i. ch. i.)

Singles. [SILK.]

Singular Roots of a Quantic. This term is applied to any system of values of the variables which reduce to zero each of the first derived functions of the quantic. (Salmon's *Higher Algebra*, p. 45.) The vanishing of the discriminant always indicates the existence of singular roots, which in the case of ternary and quaternary quantics are simply the co-ordinates of a double point on the corresponding curve or surface. [DISCRIMINANT.]

Singular Solutions. A singular solution of a differential equation of the first order, in two variables x and y, is a function of x and

y which satisfies that equation, but which is not deducible from the *general solution* or *complete primitive* by giving to the arbitrary constant which the latter involves a value absolutely independent of the variables. When the complete primitive is known, every singular solution may be deduced from it by giving to the constant c therein a value which will satisfy one or both of the conditions

$$\frac{dy}{dc} = 0, \frac{dx}{dc} = 0,$$

and conversely any solution thus obtained, and not obtainable from the primitive by giving c a constant value, is a singular solution. Geometrically a singular solution ordinarily represents the *envelope* of all the curves represented by the complete primitive, when the value of its arbitrary constant is changed. There are, however, other kinds of singular solutions whose relation to the primitive is of a more complicated character. An elaborate investigation of these will be found in Boole's *Differential Equations*, London 1859.

The singular solutions of a differential equation may also be detected without a previous knowledge of the complete primitive. To do so in the case above referred to, it is necessary to examine what relations will satisfy the differential equation, and at the same time render the partial differential coefficient of $\frac{dy}{dx}$ (taken according to y) or that of $\frac{dx}{dy}$ (taken according to x) infinite.

Singular solutions were examined, to some extent, as early as 1694 by Leibnitz, as also by Brook Taylor in 1715, by Clairaut in 1734, and by Euler in 1756. Laplace, however, in 1772 (*Mémoires de l'Académie des Sciences*) appears to have been the first to consider the general problem of the deduction of the singular solution from the differential equations; Lagrange (*Calcul des Fonctions*), Cauchy (*Moigno's Calcul Intégral*, Paris 1844), De Morgan (*Cambridge Phil. Trans.* vol. ix.), Boole, and others, have since written on the same subject.

Differential equations of higher order also often possess singular solutions, i.e. are satisfied by relations between the variables which are not deducible from the complete primitive except by supposing one or more of the arbitrary constants to be variable. The discovery of such solutions depends upon that of *singular integrals* of the differential equation under consideration, i.e. of differential equations of lower order which satisfy the given equation, and possess the above explained property of singularity.

A singular solution, as defined by Lagrange in his *Calcul des Fonctions*, of a partial differential equation of the first order, say

$$z = F(x, y, p, q),$$

where x and y are independent variables, and p and q denote the partial differential coefficients $\frac{dz}{dx}, \frac{dz}{dy}$, is found by eliminating the arbitrary constants a and b from its complete primitive, say $z = f(x, y, a, b)$, by means of the relations $\frac{df}{da} = 0$, and $\frac{df}{db} = 0$, or by eliminating p and q directly from the given differential equation by means of the relations $\frac{dz}{dp} = 0$, $\frac{dz}{dq} = 0$. Geometrically, the singular solution represents the envelope of the surface, whose equation is the complete primitive, when the parameters a and b, which the latter involves, are supposed to be *independent* of each other.

Singular Term. In Logic, a term which stands for one individual. A singular proposition is one which has for its subject either a singular term, or a common term limited to one individual by a singular sign. [PROPOSITION; TERM.]

Singularities of Curves and Surfaces. Certain distinguishing properties by means of which curves and surfaces may be classified. Multiple and stationary points, tangents, or tangent planes, &c., are examples of such singularities. Each of these is described in its appropriate place; here it may suffice to record certain important equations, connecting the ordinary singularities of plane curves, and known as Plücker's *equations*, they having been first established by that mathematician in his *Theorie der Algebraischen Curven*, Bonn 1839. If m denote the order, n the class, and δ, τ, κ, and ι respectively the number of double points, double tangents, stationary points, and stationary tangents of a curve, the equations in question are:—

$$n = m^2 - m - 2\delta - 3\kappa, \quad \iota = 3m^2 - 6m - 6\delta - 8\kappa$$
$$m = n^2 - n - 2\tau - 3\iota, \quad \kappa = 3n^2 - 6n - 6\tau - 8\iota;$$

which are equivalent, merely, to three independent equations, by means of which any three of the six numbers which they involve may be found, when the remaining three are known. The singularities here considered are called *ordinary*, because, without limiting the generality of a curve of given order or class by any special hypothesis, they may all present themselves.

In the *Cambridge and Dublin Mathematical Journal*, vol. v. Prof. Cayley has given the extension of Plücker's equations to non-plane curves.

Sinister (Lat. *left*). This word is commonly used in the sense of unlucky or unpropitious. Both in Greek and Roman divination the good omens were held to come from the east: and as the Greek augurs looked to the north, the west, or quarter of bad omens, was to their left. The Roman augur faced the south, and had the quarter of good omens on his left hand. Hence Virgil (in *Georg.* iv. 7), when he calls the propitious deities *laeva*, follows the Roman system of augury; but he

uses the word *sinister*, as the Greeks used ἀριστερός (*Odyss.* 20, 242) for things of evil omen. (*Ecl.* i. 18. &c.) [AUGURS; OMENS.]

Sinkanite. A name for the mineral Johnstonite, after one of its localities, Neu Sinka in Transylvania.

Sinking Fund. [FUND, SINKING.]

Sinopite. The Bole of Sinope. It is the *Sinopian Earth* of the ancients.

Sinople. A ferruginous Jasper, of a bright brick-red colour, found at Schemnitz in Hungary.

SINOPLE. In Heraldry, the Continental designation for the colour green; by English heralds called *vert*. The name is said to be derived, through the Crusaders, from the town of Sinope, in Asia Minor.

Sinter. A German word implying a *scale*. *Calcareous sinter* is a variety of carbonate of lime composed of successive concentric layers. *Silicious sinter* is a variety of Common Opal.

Sintoos. In Japan, the adherents of the Sinsyn (i.e. worship of the gods), the ancient religion of the country, in which the chief deity is the sun-goddess Ten-sio-dai-yin. This divinity is invoked through inferior deities called KAMI.

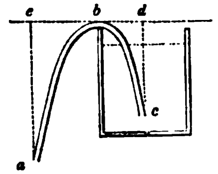
Sinuous (Lat. sinuosus, from sinus, *a curve*). In the Fine Arts, of a serpentine or undulating form.

Sinus (Lat.). In Zoology, depressions which exist in various bones or other hard parts are so called. The veins of the dura mater of the brain are also called *sinuses*.

Sinuses, Frontal. Large cavities, divided into two portions by a perpendicular osseous partition, and lined with a continuation of the pituitary membrane, secreting the lubricating mucus discharged into the nose. The extent of this frontal sinus is by no means dependent on or coincident with the degree of elevation of the supraciliary or superorbital ridges. In many recent crania of savage and barbarous men a considerable frontal elevation exists, in which no extraordinary expansion of the sinuses occurs; and Sir William Hamilton has demonstrated that it is erroneous to suppose that the extent of the sinus is indicated by a ridge, or crest, or blister, in the external bony plate. Such a protuberance has no certain or even probable relation to the extent, depth, or even existence of any vacuity beneath. In the Papuans and Australians, who approach nearest to the ape in their cranial conformation, no frontal sinus whatever exists, whilst a rather considerable frontal elevation is exhibited; in the chimpanzee in which a remarkable superorbital developement exists, no frontal sinuses have been discovered.

Sinusoid. The transcendental curve whose equation is $y = \sin x$. The curve undulates incessantly and symmetrically between two lines parallel to the abscissa axis and at the distance unity from the same. At intervals equal to π the curve crosses the abscissa axis at an angle of 45°.

Siphon or **Syphon** (Gr. σίφων, *a reed* or *tube*). In Hydraulics, a simple and well-known instrument, chiefly used for the purpose of drawing off liquids from casks. The siphon is simply a bent tube, $a\ b\ c$, having one end longer than the other. To use the siphon, the tube is in the first place filled with the liquid, and the open end a stopped by the hand, or by a cock, in which state the liquid will not flow from the other extremity. The end c is then immersed in the liquor, and the stop removed from a; upon which, if a be at a lower level than c, the liquid will immediately begin to flow out at a, and will continue to flow until the vessel is drained down to the level of c.



The principle of the siphon may be explained as follows: The lowest section of the liquid within the tube at the extremity c is subjected to two unequal pressures in opposite directions: first the pressure due to the liquid in the branch $b\ c$, which pressure is equal to the weight of a column whose length $c\ d$ is equal to the height of b above c, and tends to force the liquid out of the tube; secondly, the pressure of the external liquid at c, which is equal to the atmospheric pressure, or the weight of a column of liquor of about 34 feet in height, together with the weight of the column reaching from c to the surface of the liquid in the vessel, which, however, we may leave out of consideration. Hence, if the line cd be less than 34 feet (if the liquid be water), the last pressure will preponderate, and the liquid will be forced into the tube by a pressure equal to the weight of the atmosphere diminished by the weight of a column of the fluid equal to cd. In like manner, the pressure upon a section of the liquid at a is equal to the weight of the atmospheric column diminished by the weight of a column of the liquid equal in height to ae. If, therefore, ae be greater than cd, the pressure at c will be greater than the pressure at a, and the liquid will be forced through the tube.

From this explanation it is obvious that the limits within which the siphon can act are determined by the specific gravity of the liquid. Water cannot be raised by the siphon to a greater height than 34 feet, nor mercury to a greater height than 30 inches. It is also obvious that the comparative diameters of the two branches, and their oblique lengths, are of no importance, the action depending only on the difference of their perpendicular heights.

Sometimes the siphon is made with both branches equal, and turned up at the extremities; in which case, so long as the extremities are kept on the same level, it will continue always full and ready for use. This form of the instrument is called the *Wurtemberg*

siphon, from its having been first used in that country.

Siphon. In Zoology, the name of the membranous and calcareous tubes which traverse the septa and the interior of Polythalamous shells. The term is also applied to the tubular prolongation of the mantle in certain Univalve and Bivalve Molluscs; and by Latreille to the mouth of certain Suctorious, Crustaceous, and Apterous insects.

Siphonandraceæ (Siphonandra, one of the genera). A name proposed by Dr. Klotzsch for an order of Monopetalous Exogens, including *Vacunum*, *Andromeda*, &c. The group is not generally adopted.

Siphonapterans (Gr. σίφων, and ἄπτερος, *without wings*). A name given by Latreille to an order of insects, including those Apterous species which have a mouth in the form of a siphon.

Siphonia (Gr. σίφων). A genus of *Euphorbiaceæ*, and the source of the greater part of our supply of Caoutchouc. There are about half a dozen species. They are trees containing a milky juice in more or less abundance, though they do not all yield caoutchouc of good quality. One of them, *S. elastica*, is a

Siphonia elastica.

native of French Guiana, and the remainder of the Amazon and Rio Negro districts of Brazil. They are called Seringa-trees by the Brazilians, from the Portuguese word *seringa*, signifying a syringe or clyster-pipe, the caoutchouc having first been used for making those articles. The bulk of the caoutchouc at present exported from Pará, whence our chief supply is derived, is obtained from *S. brasiliensis*, which is common in the forests of that province; but that brought down to Pará from the Upper Amazon and Rio Negro is derived from *S. lutea* and *S. brevifolia*. These three species are all slender smooth-stemmed trees, averaging one hundred feet in height: the Pará species, however, yields the greatest abundance of caoutchouc. Europeans first became acquainted with caoutchouc in the early part of last century, and its botanical history was made known by M. de la Condamine in 1736, but it is only within the last forty or fifty years that it has become an important article in our manufactures and commerce. It exists in the tree, in the form of a thin white milk, and is obtained by making incisions in the trunk, from which it exudes and is collected in little earthen vessels, and afterwards converted into the black homogeneous elastic mass, familiar to us as Indian-rubber, by pouring the milk upon moulds, and immediately holding them over the dense smoke caused by burning the nuts of the Urucuri palms (*Attalea excelsa* and *Cocos coronata*) until it is sufficiently hard to bear another coating, when the process is repeated until the requisite thickness is obtained, and the mould is then removed. Formerly, these moulds were always in the form of shoes or bottles, and hence one of the kinds of caoutchouc is known commercially as *bottle-rubber*; but they are now frequently shaped something like battledores for folding linen, only thinner. In 1863, 65,649 cwt. of Caoutchouc were imported into the United Kingdom.

The raw seeds of these trees are poisonous to man and to quadrupeds, but macaws eat them greedily, and they are an excellent bait for fish; long boiling, however, deprives them of their poison, and renders them palatable.

Siphonifers (a word coined from Gr. σίφων, and Lat. fero, *I bear*). A name given by D'Orbigny and Ferussac to an order of Cephalopods, including all those species which have a siphon contained within a polythalamous shell.

Siphonobranchiates (Gr. σίφων, and βράγχια, *gills*). The name of an order of Gastropods, including those in which the branchial cavity terminates in a tube or siphon more or less prolonged, by which the respiratory current of water is received and expelled.

Siphonophores (Gr. σίφων, and φέρω, *I bear*). A name given by Escholtz to an order of Acalephes, to which he refers those species that have no central digestive cavity, but simply isolated tubes.

Siphonostomes (Gr. σίφων, and στόμα, *a mouth*). The name of a family of Crustaceans, comprehending those which have a siphon-shaped mouth for suction. By M. de Blainville the term is applied to those Gastropods which have the opening of the shell prolonged into a siphon.

Siphorhinians (Gr. σίφων, and ῥίς, ῥινός, *a nose*). A name applied to a tribe of swimming birds, including those which have the nostrils prominent and tubular.

Sipuncle. The name of a genus of worms which burrow in the sands of the sea-shore, and are classed with the *Echinoderms* by Cuvier, and with the *Entozoa* by M. de Blainville. They differ from the soft-bodied *Echinoderms* chiefly in the absence of ampulacral pores.

Sir. The term used in England, either out of respect or formality, in addressing any one. More particularly, it is the distinguishing appellation of knights and baronets, to whose Christian names it is prefixed. Since

the sixteenth century, the word *sire* has been used in prose only in addressing sovereign princes.

In the opinion of Professor Max Müller, the title *senior* (Lat. elder) was changed into *seigneur*, *seigneur* into *sieur*, and *sieur* soon dwindled down into *sir*. (*Lectures on the Science of Language*, first series, vi.) If, however, the word be the same as the German Herr, it is akin to the Latin herus, *a master*, the Greek ἥρως, *a hero*, a word which reappears in such names as HERA and HERACLES.

Siraballi. A valuable and fragrant timber of Demerara, supposed to be the produce of a species of *Oreodaphne*.

Siren. The generic name of certain Perennibranchiate reptiles which have only one pair of feet, and retain the external gills; they are peculiar to the southern provinces of the United States.

Sirens. [SEIRENS.]

Sirene. In Acoustics, an instrument for determining the velocity of aërial vibration, corresponding to the different pitches of musical sounds. 'In this elegant instrument the wind of a bellows is emitted through a small aperture, before which revolves a circular disc pierced with a certain number of holes, arranged in a circle concentric with the axis of rotation, exactly equidistant from each other, and of the same size, &c. The orifice through which the air passes is so situated that each of these holes, during the rotation of the disc, shall pass over it, and let through the air; but the disc is made to revolve so near the orifice that in the intervals between the holes it shall act as a cover, and intercept the air. If the holes be placed obliquely, the action of the current of air alone will set the disc in motion: if perpendicular to the surface, the disc must be moved by wheel-work, by means of which its velocity of rotation is easily regulated, and the number of impulses may be exactly counted. The sound produced is clear and sweet, like the human voice. If, instead of a single aperture for transmitting the air, there be several, so disposed in a circle of equal dimensions with that in which the holes of the disc are situated that each shall be opposite one corresponding hole when at rest, these will all form sounds of one pitch, and being heard together will reinforce each other. The sirene sounds equally when plunged in water and fed by a current of that fluid as in air; thus proving that it is the number of impulses only, and nothing depending on the nature of the medium in which the sound is excited, that influences our appreciation of its pitch.' (Sir J. Herschel's 'Treatise on Sound,' *Encyclopædia Metropolitana*.)

The sirene, as thus described, was invented by Baron Cagniard de la Tour. An instrument on the same principle, and for the same purpose, had formerly been devised by Professor Robison; but the construction was much less elegant and commodious. A current of air passing through a pipe was alternately intercepted and permitted to pass by the shutting and opening of a stop-cock.

Sirenia (Gr. Σειρήν). An order of Mammalia in which the teeth are of different kinds, the incisors preceded by milk-teeth, and molars with flattened or ridged crowns, adapted for vegetable food. The nostrils are two, situated at the upper part of the snout; the lips are beset with stiff bristles; the mammæ are pectoral. The Sirenia exist near coasts or ascend large rivers; browsing on fuci, water-plants, or the grass of the shore. The order which includes the dugongs (*Halicore*) and the manatees (*Manatus*) has existed since the miocene period.

Sirius (Gr. Σείριος, called also *Canicula*, or *Canis Candens*, the *Dog-star*). A star of the first magnitude in the constellation of *Canis Major*, or the Great Dog, and the brightest in the heavens. The Egyptians, observing that the Nile begins to swell at a particular rising of this star, paid it divine honours. [PYRAMID.]

Sirocco (Ital.). A soft relaxing wind, chiefly experienced in the south of Italy, Malta, and Sicily. It blows from the south-east or south; and having been heated over the sandy deserts of Libya, it becomes occasionally moist in its passage across the Mediterranean, and oppresses the inhabitants of the above-named countries with excessive languor and a sinking of the mental energies. The setting in of the sirocco is followed by a considerable rise of the thermometer, and is attended with a haze which obscures the atmosphere. [SIMOOM.]

Sirvente. In the Literature of the Middle Ages, a species of poem in common use among the TROUBADOURS, usually satirical, and divided into strophes of a peculiar construction.

Sismondine. A foliated variety of Chloritoid of a dark-green colour, found at St. Marcel, in Piedmont. Named after Professor Sismonda.

Sisserskite. A variety of Iridosmine, from Sisseresk, in the Ural.

Sister Keelson. The same as SIDE KEELSON.

Sistrum (Gr. σεῖστρον, from σείειν, *to shake*). A kind of timbrel, which the Egyptian priests of Isis used to shake with their hands at the festivals of that goddess.

Sisyphus (Gr. σίσυφος). In Mythology, a descendant of Æolus. By some he is said to have lived at Ephyra, in the Peloponnesus; while others allege that he was a robber, slain by Theseus. His punishment in Tartarus for his crimes committed on earth consisted in rolling a huge stone to the top of a high hill, which constantly recoiled, and thus rendered his labour incessant. The term Sisyphus is supposed to be a reduplicated form of σοφός, *wise* or *cunning*.

Sitology (Gr. σῖτος, *bread*, and λόγος). *Dietetics*, or the doctrine of aliments.

Sitta (Lat.; Gr. σίττη). The name of a bird in Aristotle, which Gesner determined to be the nuthatch. Linnæus retains the term for the genus of which the nuthatch (*Sitta europæa*, Linn.) is the type.

Sium (Gr. σίον, perhaps akin to Celt. siu, *water*). A genus of *Umbelliferæ*, consisting of strong-smelling weedy-looking plants, one of which is grown for culinary purposes, namely *S. Sisarum*, better known by its common name of Skirret. This plant, although usually treated as an annual, is a hardy perennial, a native of China, and has been cultivated in this country since 1548. The roots, for which this plant is cultivated, are composed of small fleshy tubers about the size of the little finger, joined together at the crown. When boiled and served with butter, they form a nice dish, declared by Worlidge, when writing in 1682, to be 'the sweetest, whitest, and most pleasant of roots.'

Siva. In Hindu Mythology, a title given to the Supreme Being, considered in the character of the avenger or destroyer. Sir William Jones has compared Siva to Jupiter; but he appears to share many of the attributes of Pluto. Under the name of Mahadeva, he is exhibited also as a type of reproduction: to destroy, according to the Vedantas of India, the Sufis of Persia, and even to many European schools of philosophy, being only to generate or reproduce under another form. [BRAHMA; MAHADEVA; VISHNU.]

Sivatherium. The name of an extinct genus of Ruminantia found in fossil remains in the tertiary strata of the Sivalik Sub-Himalayan range. It surpassed all known ruminants in size, and had four horns.

Six Clerks in Chancery. Officers who formerly received and filed proceedings, &c. The office was abolished by stat. 5 & 6 Vict. c. 103.

Six-points Circle. [CIRCLE, SIX-POINTS.]

Sixteenmo or **Sextodecimo.** In Printing, a sheet folded into sixteen leaves, or thirty-two pages, is thus termed. It is abbreviated 16mo.

Sizars. The lowest class of students at Cambridge. They have certain allowances made in their battels (college bills), through the benefactions of founders or other charitable persons. In college phraseology, a *size* is a portion of bread, meat, &c., allotted to a student; and hence the name *sizar*. [SERVITOR.]

Size (Span. sisa). A sort of varnish, paint, or glue, used by painters, and in many other trades. It is made of the shreds and parings of leather, parchment, or vellum, boiled in water and strained.

Skeet. On Shipboard, a scoop used for throwing water on the decks and lower sails.

Skeleton (Gr. τὸ σκελετόν, sc. σῶμα, *the dried body*). The desiccated support or framework of an animal body, which, usually consisting of different parts, may be joined together by the dried natural ligaments, is termed *a natural skeleton*; or may be articulated artificially, when it is termed *an artificial skeleton*. In the lowest organised animals, as the *Polygastria* and *Polypi*, the skeleton, when it exists, commonly consists of a single piece. In the *Polygastria* it is external, in the form of a case, and consists of pure silex. In the *Polypi* it is sometimes external, sometimes internal; and is composed of either pure carbonate of lime, or with a small additional proportion of phosphate of lime, these earths being combined with a greater or less proportion of gelatinous animal matter. In the *Isis* the skeleton consists of numerous separate calcareous joints, connected together by portions of uncalcified gelatine. In many of the Lithophytous *Polypes* innumerable minute spiculæ, of various but definite forms, are scattered through the fleshy investment of the main internal skeleton. In the *Echinoderms* the skeleton is external, as regards the viscera; but it is covered by an organised skin. It is remarkable chiefly for the great number of pieces of which it is composed, and the regular and beautiful forms in which they are combined. It likewise supports numerous tubercles or spines, and is composed of carbonate and phosphate of lime, with a gelatinous basis. In *Insects* the skeleton is partly internal, but chiefly external; and its hardening material is a peculiar animal principle, called *chitine*. In cabinets of dried insects it is the natural skeleton that is preserved. In *Crustacea* the skeleton, which bears the same relative position to the animal as in insects, is rendered denser and more brittle by being consolidated with the carbonate and phosphate of lime. In the *Mollusca* the skeleton is generally external, but sometimes internal; it is hardened by the carbonate of lime, with a very slight trace of the phosphate of lime, and constitutes the shell. The beauty, durability, and variety of form of this modification of the skeleton, have rendered the shells of the *Mollusca* at all times a favourite object of collectors, and the subject of a distinct branch of natural history, under the name of CONCHOLOGY. The skeleton of molluscs is either in one piece, as in the univalve molluscs, or in two pieces, as in most bivalves; or in many pieces, as in the multivalve chitons, and others. In the *Cephalopods*, besides the shell, which offers remarkable varieties of form and substance, there is likewise a rudiment of true internal skeleton in a cartilaginous condition. In the Vertebrate animals, there is always an internal skeleton destined to protect the central part of the nervous system, and to form the fulcrum and support of the locomotive members. In a few fishes it is cartilaginous; in the rest of the Vertebrates it is osseous, or consolidated by a large proportion of phosphate and a small proportion of carbonate of lime, and some other hardening salts. [BONE.] This is termed the *endo-skeleton*. In most fishes, in several reptiles, as the crocodilians, and in the armadillos amongst the Mammalia, osseous plates are developed in the substance of the skin; these are analogous to the skeleton of most of the Invertebrate animals, and form a more or less complete protecting case, called the *exo-skeleton*.

Sketch (Ger. skizze, Fr. esquisse). In

Painting, the first delineated idea of the artist's conception of a subject.

Sketching, Military. [FIELD SKETCHING.]

Skew Bridge. A species of bridge in which a road or railway instead of being carried over an opening at right angles with it, is carried over at some other angle, so as better to maintain the continuity of the appointed general track. In skew bridges built of stone, the joints should be spiral. There is an old skew arch at Oxford, built by William of Wykeham. Those who desire practical information about skew bridges may consult the works of Mr. Buck and Mr. Hart.

Skew Determinant. A determinant in which the conjugate constituents are equal in magnitude, but opposite in sign. Conjugate constituents, it will be remembered, are those which are symmetrically placed with respect to the principal diagonal, so that if, generally, $a_{i,k}$ denote the k^{th} constituent on the i^{th} line of a skew determinant of the n^{th} order, we shall have, for all *unequal* values of i and k, $a_{i,k}+a_{k,i}=0$.

Skew Helicoid, commonly called **Screw Surface.** [HELICOID.]

Skew Quadric. A skew surface of the second order. There are two such surfaces: the Hyperboloid of one sheet, and the Hyperbolic Paraboloid. [QUADRIC.]

Skew Surface. A ruled surface of which two successive generators do not in general intersect. The most familiar examples are the hyperboloid of one sheet and the hyperbolic paraboloid; the first generated by the motion of a line which rests on three straight lines [RULED SURFACE], and the other generated by a line which rests on two straight lines and remains parallel to a plane. [CONOID; HELICOID.] The tangent plane at any point of a skew surface contains the generator through that point, which generator is one of the inflexional tangents; conversely, every plane through a generator touches the surface at the point where this generator is intersected by the line joining the intersections of the plane with the next two generators; this latter line is the second inflexional tangent. The hyperboloid generated by a line resting on three consecutive generators of a skew surface [RULED SURFACE], touches the latter along the whole length of one of these generators. The tangent planes through a generator obviously correspond anharmonically with their respective points of contact. [HOMOGRAPHIC.] The points of contact a and a' of pairs of rectangular planes A and A′, through the same generator form a system in involution, the centre of which is the point o *nearest* to the next succeeding generator; for the two inflexional tangents at that point are perpendicular to one another, and the normal plane at o through the generator is parallel to the next generator, and consequently touches the surface at infinity. The point o, therefore, is on the *line of striction*, and the points a and a' on any generator at which a given plane, through the latter, is tangential and normal, respectively, are so distributed that $oa.oa'=$ const. Since the normal planes which pass through the generator correspond anharmonically to the points a at which they are normal, the normals themselves will generate a hyperbolic paraboloid, having the generator itself for a line of striction. The *order* of a skew surface being equal to the number of generators which meets any line, is also equal to its class, since every plane through the line and a generator is a tangent plane. The polar reciprocal of a skew surface, therefore, is another skew surface of the same order. Every plane through a generator of a skew surface of the n^{th} order meets the surface, of course, in a curve consisting of that generator, and a curve of the $(n-1)^{th}$ order; the latter meets the generator in $n-1$ points, one of which will obviously be the point of contact of the plane of the section, and will vary as that plane rotates around the generator; the other $n-2$ will remain fixed during this rotation, and, being points where the generator is met by other generators, will be points of a *double* or *nodal curve* on the skew surface. In general, therefore, we may say that a skew surface of the n^{th} order has, on its surface, a double curve, which is met by each generator in $n-2$ points. Every skew surface satisfies a partial differential equation of the third order, which may be obtained by expressing the condition that the tangent planes at three consecutive points of a generator all pass through the latter. The method of obtaining this equation is explained in all good text-books.

Skew Symmetrical Determinant. A skew determinant whose principal constituents vanish. If $a_{i,k}$ denote, generally, the k^{th} constituent of the i^{th} line of such a determinant S of the n^{th} order, then for *all* values of i and k we have the relation $a_{i,k}+a_{k,i}=0$, which of course implies the vanishing of every principal constituent such as $a_{i,i}$. Since the multiplication of every constituent of S by the factor -1 is equivalent, on the one hand, to the multiplication of the whole determinant by $(-1)^n$, and, on the other hand, in virtue of the above relation to the mere substitution of rows for columns we have the relation $S=(-1)^nS$ [DETERMINANTS]; from this it follows that every skew symmetrical determinant of *odd* order vanishes identically. By equally simple reasoning it can also be proved that every skew symmetrical determinant of *even* order is an exact square. Its root consisting of $(n-1)\ (n-3)\ .\ .\ .\ 3.1$ terms, with $\frac{n}{2}$ factors in each term, is called a PFAFFIAN. Thus

$$\begin{vmatrix} o, & a, & -b, & c \\ -a, & o, & f, & e \\ b, & -f, & o, & d \\ -c, & -e, & -d, & o \end{vmatrix} = (ad+be+cf)^2$$

Further, if $a'_{i,k}$ represent the coefficient of

$a_{i,k}$ in S; i.e. if $a'_{i,k}$ be a first minor of S, and therefore a constituent of the determinant S' of the reciprocal system, then $a'_{i,k} = (-1)^{n-1} a'_{k,i}$; so that S' is symmetrical when n, the order of S, is odd, and skew symmetrical when n is even.

Skewback. In Architecture, the sloping abutment, in brickwork and masonry, for the ends of the arched head of an aperture.

Skid (akin to Ger. scheiden, *to cleave*). A square piece of timber of some length. Also an iron shoe for checking the revolution of a wheel.

SKID. In a ship, any beam or timber used as a support for some heavy body to prevent its weight falling on a weak part of the vessel's structure.

Skid-beams. Timbers laid across the waist of a ship to support the larger boats, especially the launch.

Skiff (another form of the word SHIP). A small light boat, propelled by one man with a pair of sculls, but not of any special build.

Skimmia (Japanese skimmi). A genus of remarkably ornamental evergreen shrubs, with oblong entire leathery dotted leaves, and flowers in terminal panicles, succeeded by bright red drupe-like berries. *S. japonica* is a pretty dwarf-growing holly-like shrub, with dark shining entire leaves and clusters of bright red berries, which give the plant a very handsome appearance. It is now commonly cultivated. The genus is referred by the latest authorities to *Rutaceæ*, but it has considerable affinity with the Orange family.

Skin. The external covering of the body. It is divisible into three parts or membranes. The exterior is called the *scarfskin* or *cuticle*: it is an albuminous membrane. Immediately underneath it is a thin layer of soft or pulpy matter, called *rete mucosum* (mucous network), which is the seat of colour: it lies upon the *cutis*, or true skin, which is a gelatinous texture.

Skink (A.-Sax. scenc). A genus of Lizards in which the legs are dwarfed and in some species almost altogether suppressed, and the tail attains great length.

Skip (Fr. esquiver). In Music, a passage from one sound to another by more than a degree at one time.

Skipper (Dan. from skiff and ship). A name applied to the masters of merchant vessels.

Skirmish (Fr. escarmouche, Ital. scaramuccia). A desultory engagement between troops not in compact bodies.

Skirting. In Architecture, the narrow vertical board on the floor round the sides of an apartment.

Skögbolite. A name proposed for the Tantalite from Skögbole, and Härkäsaari in Finland.

Skolezite. [SCOLEZITE.]

Skolopsite. A silicate of alumina, lime, soda, and other bases, considered by Rammelsberg to be analogous to Sodalite, Nosean, &c. It forms a crystalline granular mixture with a dark-green Pyroxene, in the dolerite of the Kaiserstuhl in Breisgau.

Skorodite. [SCORODITE.]

Skorzite. A Mineralogical synonym of a variety of Epidote, from Skorza.

Skull (Dan. skal, Dutch scheel). The term applied by osteologists to the bony case formed of the coalesced arches of the four peripheral vertebræ of the spinal axis. It is formed of four segments; the occipital, being the epencephalic and the scapular arches; the parietal, being the mesencephalic and the hyoid arches; the frontal, being the prosencephalic and the mandibular; and the nasal, being the rhinencephalic and maxillary arches. This assemblage of vertebræ is connected with the spinal series by two condyles (the neural elements of the occipital bone) or exoccipitals, articulating with the atlas, or first cervical vertebra, which rotates upon the axis.

Skunk. A plantigrade carnivorous mammal (*Mephitis*) found in the New World, where eighteen species are known, eight of which are found in North America, and ten in South America. The genus is specially distinguished by its exceedingly large anal gland, which exhales a putrid and offensive odour, shed by the animal when annoyed or irritated. The scent is so powerful, that it endures for many years.

Skunkweed. The name of the curious stinking North American *Symplocarpus fœtidus*.

Skutterudite. The native arsenide of cobalt found at Skutterud, near Modum, in Norway. It occurs both crystallised and massive, of a colour between tin-white and lead-grey, with a metallic lustre and occasionally an iridescent tarnish.

Sky, Colour of. Various hypotheses have at different times been suggested to account for the blue colour of the sky. Some, with Newton at their head, attribute it to very fine aqueous particles of such thickness as to cause the interference of the yellow waves of white light, thus leaving unneutralised the complementary blue waves. [INTERFERENCE.] Clausius believes, that to procure such an effect the little particles of water must not be little globes, but hollow spheres or vesicles. Others attribute the phenomenon to the greenish blue colour which aqueous vapour, like liquid water, probably possesses; but the blue of water is very different in tint from that of the sky on a bright clear day; moreover, even when the air is very moist it would require the light to pass through a stratum of about 200 miles thick to produce by absorption the green-blue tint observed on looking at a white object through a stratum of water 15 feet thick. The peculiar greenish hue which the sky sometimes assumes in wet weather near the horizon may, however, be due to this cause. Hitherto the blue colour of the sky cannot be said to have received a satisfactory explanation.

Sky Rocket. [ROCKET.]

Sky Sail. A small sail set, on rare occa-

sions and in very light winds, above the royal, on a pole temporarily hoisted for the purpose.

Skylark. The name of a species of the genus ALAUDA; the *Alauda arvensis* of Linnæus.

Slab (Welsh yslab). The name given to large solid and massive slates obtained from the quarry for special purposes. A slab measuring twenty feet by ten and several of somewhat smaller size were exhibited at the International Exhibition in 1862, by the Llangollen Slate Company. They were among the finest and largest ever quarried. [SLATE.]

Slab Line. A small rope leading through a block under the lower yards, and thence to either foot of the sail for the purpose of *tricing* it up.

Slack. Small coal under the size of an egg.

Slag (Dan. slagg). The imperfect glassy or vitrifiable compounds which are produced during the reduction of metallic ores by various fluxes. In the neighbourhood of large smelting works, especially of iron and copper, the slags, which are abundantly produced, are sometimes used as building materials, and for making and mending roads. They often contain a considerable relative proportion of metal.

Slander (Fr. esclandre). In Law, a malicious defamation of a man by words spoken. It is not actionable unless it impute some crime punishable by law; or some contagious disease, which may have the effect of excluding from society the person slandered; or be uttered concerning him in his trade or business in such a way as to impair his means of livelihood; or, lastly, unless it be attended with special damage. A defendant cannot be proceeded against criminally for words spoken, unless they have a direct tendency to a breach of the peace, as by containing a challenge to fight; or are of a seditious or grossly immoral character; or are spoken of a magistrate in the execution of his duty.

Slate or **Clay Slate** (Swed. slita). In Geology, the name given to a very remarkable form of clay rock, frequently fossiliferous and not confined to one geological period. Consisting essentially of clay, the particles of slate are so mechanically arranged, that the rock splits with perfect facility into almost indefinitely thin layers in one direction only, and in all others either breaks with a jagged edge, or in well-defined joints at some distance from each other.

Mineralogically, slate is nothing more than a pure clay; nor does there seem any reason to suppose that any approach is made in it towards crystalline structure. As, however, no other rock shows this tendency to split indefinitely, the case is one of great interest.

Practically, slate is very valuable, owing to its peculiar facility of splitting, and the perfectly smooth natural face which it presents. Its hardness and compactness preserve it from all weathering by mere exposure, though, when ground down, it easily passes back into fine clay.

Slate is always, and properly, regarded as a metamorphic rock. It has certainly undergone much change, though it is not quite certain what the change may have been. In many parts of it crystals of iron pyrites, and sometimes strings and veins of copper pyrites, occur; gold is not unknown in it, and magnetic and other oxides of iron have been found in it. Crystalline garnets are also found occasionally, and curious nodular masses of minerals are segregated into irregular spaces formed in its substance.

The most reasonable explanation of the condition of slate is, that it has undergone enormous squeezing, and that as this squeezing has acted on a rock of which the particles readily adapt themselves without fracture to any required shape, they have been brought into this curious parallel arrangement. The condition of the fossils fully supports this view, as they are almost always squeezed and distorted. A careful examination of the microscopic structure also yields evidence of the same kind.

Slates are not very common. The British Islands are, however, so rich in different varieties, that all in this country are familiar with them. Cornwall, Wales, Scotland, and Ireland all afford quarries of great magnitude, the profits of working which are among the largest obtained in mineral works, in comparison with the amount of capital invested.

The quantity of slates used is very large: at least fifty thousand tons are consumed annually in London alone, although in that city, for local reasons, the houses are generally roofed with tiles. Slates are largely consumed by almost every town and village in the kingdom. More than two-thirds the quantity of slates raised are used for roofing. For this purpose the slates are cut into sizes varying from a few square inches to two square feet, though some are much larger. This is done with very simple tools and extreme rapidity. The rest is in slabs or thick slates, often very large. [SLAB.]

The use of slate and slabs has increased enormously of late years, and is still increasing. Slabs are now used largely in house fittings; as in strong rooms, powder magazines, larders, partitions, baths, stables, floors, drains, &c. For all these, and many like purposes, its perfect resistance to the atmosphere, to all chemical influences, and to the passage of heat, render it invaluable. It has been very largely used also for enamelling; the surface of enamelled slate being made to represent marble of all kinds with wonderful accuracy, and resisting almost all wear. Thus, for mantelpieces, billiard tables, ornamental slabs, and furniture, it has no equal, its cheapness being such as to drive other material out of the market.

The dimensions of the larger quarries, and the number of hands employed in them, render slate one of the most interesting and important of all mineral manufactures.

Many excellent slates are obtained abroad.

Those from the Ardennes, from Angers on the Loire, and from Nassau, are largely exported.

Slate Coal. Coal with a slaty structure, and an uneven and small-grained fracture. The rich caking coal of Newcastle is referred to this variety; as is also the greater part of the coal of the Coalbrook Dale coalfield in Shropshire.

Slate Spar. A massive variety of carbonate of lime, of a shining, white, pearly lustre, and often with a greasy feel; found at Wicklow, in Ireland; Strontian and Glen Tilt, in Scotland; Botallack, and other Cornish mines; at Polgooth mine in Devonshire, and at Coniston in Lancashire; also in Norway and Saxony.

Slave Trade. This term generally denotes the trade in slaves carried on by European nations between the western coasts of Africa and the American settlements.

The European slave trade is generally supposed to have been commenced by the Portuguese about the end of the fifteenth century. About 1508, the Spaniards began to import negroes into America, to supply the place of the Indians, whose numbers were rapidly diminishing under the severity of the toil to which they were exposed by their conquerors. Sir John Hawkins, one of Queen Elizabeth's most famous captains, seems to have been the first Englishman of note who embarked in this traffic, having been concerned in the sale of negroes to the Spaniards in the West Indies. In the same reign the African Company was first chartered, for the purpose of trade with Guinea. This company carried on a trade in negroes with the English settlements in America from the beginning of the seventeenth century to the year 1732. From this period that traffic was carried on chiefly by private traders. It was not until the latter end of the eighteenth century that the atrocities of this trade began to engage the attention of parliament. In 1788, an Act was passed to regulate it; and after twenty years' animated discussion it was at last totally abolished in 1807. The United States of America and Denmark had preceded us in this righteous act. (Clarkson's *History of the Abolition of the Slave Trade.*)

The slave trade is now prohibited by the laws of most European nations except Portugal; and by the law of that country it can be carried on only within certain geographical limits. Nevertheless, it is still followed to some extent by contraband dealers. According to some estimates, about 75,000 slaves are supposed to be annually carried from their homes in Africa to supply the American markets, including those who perish by the way. There can, however, be no doubt that this estimate is very greatly exaggerated; and it may be doubted whether, taking those exported from the east coast to Arabia, &c., into account, the average number of slaves carried from Africa during the ten years ending with 1850 can have been as high as 40,000 a year; since that time even this exportation has probably been materially reduced. The principal importing countries are Cuba, Porto Rico, and Brazil. Publications on the slave trade are so numerous, that it is difficult to make a selection for purposes of reference. Perhaps (after Clarkson's *History*) the student could not find the account of its progress better given than in successive numbers of the *Edinburgh Review*, especially vols. xxi. xxiii. xxiv. xxxvi. cix. cxv.

Slave Trading or **Slave Dealing.** In Law, slave trading, on the high seas, accompanied by a forcible carrying away of the slave, was made piracy, felony, and robbery, by 5 Geo. IV. c. 113, s. 9. And by s. 16 of the same statute a number of other acts relating to and in furtherance of dealing in slaves are made felonious. This is one of those offences of which British law takes cognisance if committed by British subjects in regions out of British dominion.

Slavery. In Moral Philosophy. This term, denoting a state of absolute bondage or total loss of liberty, owes its origin to the vast numbers of Slavonic captives with which Spain became filled during the wars of the Frank kings; and thus a national designation, meaning in its own tongue *glorious*, became the common title of servitude. (Freeman, *History and Conquests of the Saracens*, 195; Gibbon, *Roman Empire*, ch. lv.) But the condition of slavery has been found originally in all countries, and subsists to this day over the larger portion of the earth. The liberty of the ancient world, whether at Athens or elsewhere, was only the freedom of a class, and in the states which were most free implied, perhaps, most of all the existence of a class of men who were not free. [PRIMARY ASSEMBLIES; LIBERTY.] 'We lose a good deal of our sympathy with the spirit of freedom in Greece and Rome, when the importunate recollection occurs to us of the tasks which might be enjoined, and the punishments which might be inflicted, without control either of law or opinion, by the keenest patriot of the Comitia, or the Council of Five Thousand.' (Hallam, *Middle Ages*, ch. ii. part ii.)

According to Aristotle (*Polit.* i. 1), the distinction between despot and slave was as strictly a distinction of nature as that between male and female. Nothing can be clearer than the language in which he asserts that slaves and women are destitute of the natural capacity for government, this capacity being dependent altogether on intellectual foresight, in which they have no share. Hence the great body of slaves, and the great body of masters or despots, form each a distinct whole, set by nature one against the other, ἓν πρὸς ἕν. Hence the slave was merely an animated machine, κτῆμά τι ἔμψυχον, and such he must continue, as much as a woman must remain a woman. This distinction was, however, rather the theoretical than the practical foundation of Greek or other ancient slavery, and Aristotle is obliged to allow (*Polit.* i. 6. 1) that the word δουλεία, *slavery*, is susceptible of more than one meaning, and that war and other causes were constantly reducing into the ranks of slavery

those who had been born free, and who may have risen to the highest distinction as statesmen and philosophers. On this subject, which involves the most horrible aspect of all ancient civilisation, Aristotle can only multiply sophistical quibbles. It is a legal principle, he tells us, that things taken in war shall be in the power of the taker, and all men taken in war are things; and at all events, whatever be the justice of the principle, he finds some comfort in thinking that superiority of force, which is implied in the idea of victory, implies also a greater excellence or virtue (ἀρετή) in the conqueror than in the conquered. This theory acted necessarily with great force on the Greek and Roman feeling of patriotism. Underneath its apparently exalted character lurked an intense selfishness; the struggle was for something of which at any moment the citizen might be himself deprived, and of which he was quite ready to deprive others; and thus, in the words of Macaulay (*Essays*, Machiavelli), patriotism became with them a governing principle, or rather an ungovernable passion.

The Aristotelian argument, grounded on natural distinctions, is as an argument beneath contempt, and could have been maintained only by those who were obstinately bent on holding their position, whether logically tenable or not. The necessary result of a natural distinction is, that it is accepted as unalterable, and acquiesced in. Individual women may be found to express discontent at certain circumstances in their condition; but no course of action has ever been taken by bodies of women for the express purpose of abolishing the natural distinction which marks their sex. Natural distinctions, again, admit of no exception; all women know themselves to be women, and the occurrence of individuals who could not be classed in the natural order of men or women would upset the natural distinction. In both these points, the theory of Aristotle breaks down. The slaves have not universally acquiesced in their condition; and among slaves many have not exhibited the marks which Aristotle asserts to be essential to a slave. The whole history of the ancient world attests a general fear of the slaves on the part of their masters, and a constant readiness on the part of the slave to rebel against his masters. Whatever may have been the nature of the Spartan CRYPTEIA, we have undoubted historical evidence which proves that the Spartans could by a pretended gift of freedom entrap hundreds of men, whose bravery they dreaded, into a destruction, accomplished no one ever knew how. In Italy the discontent of the slaves broke out from time to time into formidable rebellions and wars; and the whole Roman law of slavery implied an utter distrust of the fancied natural distinction on which Aristotle grounded the justice of the system, for with him slavery was not an institution, but a necessary phase of human nature. The execution of the whole familia of Pedanius, 400 in number, by order of the senate in the time of Nero, because one slave, being refused his liberty, had slain his master, is but one example of a method of treatment which took for granted that the slaves did not and could not acquiesce in their position as an ordinance of nature.

There were other circumstances under which the theory of Aristotle became not only contemptible but ridiculous. The essence of his definition of slavery is that the foresight of the slave is simply that of the mole or the beaver. His masters have intellectual power (διάνοια); he has only a bodily instinct (προορᾶν σώματι); but as he has only this, it is as impossible for him to rise to anything higher, as it is for an elephant or a monkey to take part in the debates in the House of Commons. Yet, under pressure in time of war, Athenian masters were ready enough to enfranchise all slaves fit for bearing arms; and thus to let loose upon society beings who, according to the Aristotelian theory, were simply able-bodied bears or wolves. (Grote, *History of Greece*, part ii. ch. xc. vol. x. p. 694.)

If, again, the idea of a class of natural slaves is set aside by the appearance, among slaves, of individuals endowed with high intellectual powers, the idea of a class of natural rulers is also upset by the appearance, in oligarchic or aristocratic bodies, of persons of debased minds and slavish wills; and, whatever may be said of the latter, it becomes sheer injustice if the former be condemned to a life of slavery. Hence, Aristotle strove hard to prove that nature made the bodies of slaves different from the bodies of natural rulers, and doubtless shut his eyes to slavish bodies which he saw from time to time whether in the Macedonian court or in the houses of Athenian citizens.

At Athens, therefore, or in Rome, the treatment of the slave depended almost entirely on the will and disposition of the master; and the rules given in the so-called Aristotelian *Œconomics* (i. 5) are addressed simply to the self-interest of the owner, and not grounded on any legal, far less on any moral, rights of the slave. For a slavery more merciful in theory, and probably far less hateful in practice, we must look neither to Greeks nor Romans, but to the Jews, whose system, as depicted in the Pentateuch, contrasts most favourably with the slavery not only of the Turks, but with that more horrible form of bondage which prevailed in our West Indian colonies, and was maintained to a later time by the Southern States of the American Union. In his *Treatise on American Slavery*, Professor Goldwin Smith has shown that the Mosaic legislation recognised a common bond of interest between master and bondman, and threw over the latter the protection of the law; that it made no distinction between his testimony and that of the freeman; that it sanctioned his marriage, and recognised his family, while it united the slave and his master in every act of religious worship, and upheld the honourable character of manual labour. He has further shown that the American slave system cannot exist without a fugitive slave law, while the

Mosaic legislation bids the Jews rather to run the risk of war than to give up the runaway slave. In the Mosaic, and even in the Turkish system, the child follows the condition of the father; it was reserved for slave-owners calling themselves Christians to look on the faces of their children and receive in dollars the recompense for the sale of their own blood. The serfdom introduced by the German tribes differed from the slavery of the ancient world only, perhaps, in the obligation which tied the villein to the estate of his lord. (Hallam, *Middle Ages*, ch. ii. part ii.) [SERF; VILLEIN.]

In the civilisation of modern Europe, slavery, having passed through the phase of serfdom, has been gradually weakened and abolished. But 'the great change in the condition of the servile order arose chiefly from other causes, besides the influence of Christianity.' (Milman, *Latin Christianity*, book iii. ch. v.) Asserting that the influence of Christianity must have tended from the first to mitigate the horrors of slavery, Dean Milman thinks that in the later Roman empire it was rather the multiplication of slaves which slowly wrought its own remedy. It is quite certain that the Christian Church did not from the first enter the lists against the principle of slavery. 'The Churches themselves were slave-holders; there were special provisions to defend their slaves,' and, by some Teutonic codes, whoever concealed the slave of an ecclesiastic was condemned to a triple fine. The laws of Justinian not only recognise slavery as a permanent institution, but 'ascribe to the heathen sovereign Antoninus, the great change which had placed the life of the slave under the protection of the law. . . . But the abrogation of slavery was not contemplated even as a remote possibility. A general enfranchisement seems never to have dawned on the wisest and best of the Christian writers, notwithstanding the greater facilities for manumission and the sanctity, as it were, assigned to the act by Constantine, by placing it under the special superintendence of the clergy.' Even as so amended, the Christian slavery of Justinian was far inferior to the Jewish slavery of the Pentateuch. The testimony of the slave could be received against his master only in cases of high treason, and his union with his wife was still only concubinage, not marriage. 'Basil the Macedonian,' in the ninth century, 'first enacted that the priestly benediction should hallow the marriage of the slave; but the authority of the emperor was counteracted by the deep-rooted prejudices of centuries. It was the weakness of Rome, not her humanity or Christianity, which, by ceasing to supply the markets with hordes of conquered barbarians, diminished the trade' in slaves, and thus hastened the downfall of the institution.

It may further be remarked that the Aristotelian theory of natural distinctions might derive a plausible colour from the notions entertained by some as to the characteristics and destiny of the negro race. But the slaves of the Greeks and Romans (even if we take into no account those who were reduced to slavery by debt or the fortune of war) were of no such alien race, although they may have represented those earlier possessors of the soil who were conquered by the Dorians, Ionians, or Latins. The Jewish slavery was confined to that of bought slaves: no Hebrew could be permanently retained in bondage, and his servitude, as Mr. Goldwin Smith remarks, 'was, in fact, not slavery at all, in the proper sense of the term.' But it is obvious that the theory of a natural distinction like that of Aristotle cannot be maintained, if the supposed servile class has a capacity for amalgamation, and does in fact amalgamate with the ruling class. Among the Greek and Roman bondmen there were many born slaves, whose forefathers had been free citizens, deprived of their freedom for debt. In the English West India islands and in the Southern States of the American Union, a considerable proportion of the children of negro slave women were or are the children of white slave-owners. The idea of a natural distinction is thus summarily rejected even by those who may be most interested in maintaining it.

To slavery in Europe the deathblow was given by the refutation of notions based on an antipathy to labour as contemptible and degrading. The real idea of slavery is that of a large class condemned to servile toil, in order that a narrow class may be altogether idle. Such an idea is antagonistic with the whole spirit of modern European civilisation: and wherever this spirit finds its way, slavery must decline and eventually perish.

For the theories of Bodin and others on slavery, see Hallam, *Literary History*, part ii. ch. iv.; Lecky, *History of Rationalism*, ch. vi.

SLAVERY. In Political Economy. The practices of exacting compulsory labour, and of recognising the right on the part of some members of society to hold others to involuntary bondage, are found universally in the customs and laws of both ancient and modern communities. Labour is a condition of existence, but it is on the whole disliked, shortened, and as far as possible avoided, either by laying it on others than those who reap its advantages, or by employing natural forces in lieu of muscular exertion. Such natural forces can be used very scantily in the early stages of social developement; and slavery, the easier and more obvious means for avoiding labour, is thus generally practised in primitive, uncivilised, or imperfectly civilised communities. But we shall see that the adoption of this alternative as a means for economising or avoiding labour, is the most permanent among the hindrances to any real progress in those mechanical arts which tend to shorten human labour, and thus put the largest amount of conveniences at the least possible cost within the reach of the greatest number of persons. Though the origin of slavery is found in economical influences or motives, the retention of slavery is a permanent impediment to the developement of the best economical state.

Slavery existed in all ancient communities, and in several forms, side by side with great intellectual activity, and with unexampled skill in the fine arts. It is compatible with great progress in the sciences of law and government. But the mechanical arts are very scantily developed wherever slavery exists, even in its modified forms; and even when these arts have been partially discovered, their growth has been arrested, or their application dwarfed, by its pressure. The ancient world was almost entirely ignorant of the inductive sciences, though the passion for physical study and research was very keen, and the advantage of possessing these sciences as the means of economy within the state, and of protection from external aggression, was obvious. The cause of this imperfect growth is to be found in the prevalence of slavery.

Slavery arose historically, as far as can be traced, from war, from piracy—if indeed the two can be distinguished in early times—and from the penalties levied on offenders against persons and property. As, according to the original theory, the life as well as the fortunes of the vanquished are at the discretion of the conqueror, slavery was at its beginning a humane or merciful substitute for the exercise of these extreme rights, like the ransom which the captor exacted from his prisoners in the middle ages. So, again, the slave market of the ancient world was supplied (in default of captives taken in war) by descents on the coasts of foreign races, and probably also by the purchase of foreign captives, whom their captors disposed of to the Greek, Carthaginian, or Asiatic merchant. Sometimes, especially in the eastern world, the tribute of a conquered region was expressly defined by the supply of a certain number of male and female slaves. Again, in early systems of jurisprudence, laws are intended rather to protect individuals, and to recompense individual wrongs, than to vindicate or secure the well-being of society. The latter object of judicial procedure was too refined and abstract to be comprehended in these early ages. It would not have suited the notions of justice which prevailed in communities, among whom public ties were slight, and intense only under particular emergencies. And even when the doctrine of obligation to a central authority, and the vindication of injuries against the constitution or the vitality of society were recognised, the means adopted were rather a control over the acts, lives, and customs of men, than a system of punishments which remedied private wrongs only indirectly. Hence, when the judge took cognisance of injuries committed on private persons, his decision generally assumed the form of a fine, or, if the criminal was unable to pay the fine, an adjudication of his person to the injured parties as the fairest and fullest satisfaction which could be made. Such a means of compensation, known in ancient Rome, was exceedingly common among nations of Germanic origin, and in times of violence must have been a frequent cause of slavery.

Again, as debt was treated as a species of civil crime, and as persons in these states of society were permitted to pledge themselves and their families as security for loans contracted, defaulting debtors were, either by the terms of their contract, or by judicial decisions, assigned or adjudged as slaves to their creditors. [SEISACHTHEIA.] The two forms by which such a result occurred in ancient Rome are discussed by Niebuhr and Savigny. A slight trace of this custom in England may perhaps be discovered in those ancient forms of obligation known as STATUTE MERCHANT and STATUTE STAPLE, as the custom of imprisonment for debt was a substitute for personal slavery consequent on an adjudication upon a civil plea and the issue of execution.

Slavery is either absolute or partial, the latter being generally called *serfage*. [SERF.] In the former case, there is a denial of all personal rights, and of all property to the slave. But humanity and policy have rarely permitted this total extinction of all rights in the slave, whenever, at least, the community has stood above the level of the merest barbarism. Thus, in Athens, an ill-used slave could take refuge in the temple of Theseus, and demand that his master should sell him. Assaults on slaves were punishable by indictment, and no slave could be put to death without trial. In Rome, he was permitted the possession of property, under the name of *peculium*; and though the treatment to which he was subject was harsher, it appears, than in Greece, we must take into account, in explanation of this fact, that authority was largely and unsparingly exercised by the Roman husband and father over his wife and children. It cannot be doubted that the comparative lenity with which the slave was treated in the ancient world, must, all circumstances considered, be ascribed to the fact, that many of those unfortunates were of the same or nearly the same origin with their lords, and that the social difference between them was not aggravated by fundamental distinctions of race or colour.

Slavery was virtually extinct throughout European Christendom at the time in which the New World was discovered. It is true that penal servitude of a very severe character still existed in the condemnations to the galleys. But penal servitude stands on a totally different footing from slavery; though, under the form of transportation, its effects on the object of the sentence were to reduce him either permanently or temporarily to the condition of a slave.

The first occupation of the New World was accompanied by the enslaving of its inhabitants, in those regions at least where the Spaniards and Portuguese found an abundant population and a settled government. The natives were constrained to labour in the mines and other kinds of toil, adverted to above, under the title PEONAGE. By these means the population was nearly extirpated. To save

the remainder, the benevolent missionary Las Casas recommended the importation of negroes; the slave trade was commenced on the western coast of Africa, and a large negro population was introduced into the New World. The other European nations followed the example of Spain in all their American colonies, and a slavery of race and colour became general. The traffic in slaves, though atrociously cruel, was exceedingly profitable, and the interest of a large and influential body of merchants was enlisted in the trade. The slaves were collected on the low coast of South-Western Africa at very cheap rates, were stored in stifling vessels, and transported across the Atlantic. The rate of mortality during the passage was enormous, but the price of the slave on the coast amply compensated the loss, even when the per-centage of deaths was exceedingly high. Gradually philanthropists called attention to the traffic, and, in spite of many obstacles, the slave trade was suppressed and treated as piracy, almost all European nations having concurred in the schemes for stopping or at least for checking it. But as these measures were not generally coupled with the emancipation of negroes in the several American governments and colonies, the effect of legally abolishing the slave trade was only that of making the sea passage more difficult, and of raising the price of the slave in the New World.

Slavery was abolished in the British colonies in the year 1834, the owners being compensated by a grant of twenty millions. Several of the northern states in the American Union had, however, decreed the extinction of slavery long before this time. Its final extinction in the Union was the fruit of the late war, as the attempts to extend it on the one side and to limit it on the other were the cause of that gigantic struggle. It still exists in the Spanish dependencies of Cuba and Porto Rico, and in Brazil; but a considerable and increasing party in Spain is pledged to the abolition of slavery in the Spanish colonies.

In general, it may be stated that slavery was exhibited in its harshest and most repulsive features on the American continent. Nothing interfered practically between the will of the master and the sufferings of the slave; for although some laws were enacted for the protection of the slave, evidence that these laws were broken was in any case difficult, and was generally unattainable, since the slave was precluded from being heard in a court of justice. There were no limits to the hours of labour, except the interest of the slave-owner in the slave's life, and this interest was a very weak guarantee against the prospect of immediate gain, or the impulse of uncontrolled passion.

The effect of slavery, and especially of negro slavery, on those communities in which it is encouraged, protected, or permitted, is twofold —moral and economical. It induces habits of lawlessness and licentiousness; the former by the fact that great powers of repression, or at least of independent action, must be accorded to the slave-owner; the latter by the ease and impunity with which passion is gratified. The evidence on the latter head is overwhelming, especially from those who have witnessed the effects of slavery in Brazil.

Its economical effects are numerous. By the degradation necessarily connected with the social position of the slave, labour is disparaged and discredited. The backward state of all slaveholding communities, and (even where they have reached a certain state in wealth) their rapid declension, are notorious facts. Besides, as the capital of the slave-owner is to a great extent invested in his slaves, so the whole weight of bad harvests and adverse markets falls on the owner. Where labour is free, national losses affect, as a rule, all classes equally; where it is compulsory, these losses fall entirely upon capital or profits. Again, there is always, when labour is free, an impulse affecting capitalist and labourer alike, towards shortening or economising labour as fully as possible. The labourer is impelled to get the highest remuneration at the least labour; the capitalist, still more effectually, to achieve the highest price at the least cost. Hence the improvements in machinery, which have characterised the condition of free labour. But in a state of slavery such a disposition to economy would not affect the master, partly because labour by the very existence of slavery is relatively cheap; partly, because compulsory labour cannot be depended on, except for the simplest operations. Still less, however, is the slave disposed to economise his labour by the use of any substitutive instrument, as he has no interest in his own effectiveness. It was from the prevalence of slavery that no progress, or no important progress, was made in the industrial arts among ancient nations. Lastly, as labour is exercised under the most disadvantageous conditions when it is compulsory, so it is most exhausting to the soil. With such a social state, a community needs perpetual additions to its area; and it will be found, whatever be the pursuits of such a community, that it needs a far larger territory to support an equal population than countries of which the soil is free.

Slavonic Languages. A name applied to the dialects of Lithuania, Russia, and Poland, the speech of the Slavonic tribes who began their advance into Mœsia and Thrace in the fifth century, and were settled in Macedonia in the following century. The most ancient document of the Bulgarian and Illyrian, or eastern branch of the Slavonic, is the translation of the Bible made by Cyril and Methodius in the ninth century. [LANGUAGE.]

Sledge (A.-Sax. slecge, Swed. slagga). A vehicle without wheels, used as a means of locomotion on snow. Sledges are used during the winter in Canada and Russia, &c.; but the country with which the name is most associated is Lapland, where two kinds are used; the one being the pulk or close sledge for the use of

travellers and merchants, the head being pointed like a canoe, and the body being covered by an oval half-deck, covered with seal skins. This sledge is generally about seven feet in length, sixteen inches in breadth, and eight inches in depth. For the conveyance of goods a longer sledge is used, which has no deck. A single reindeer will draw a sledge at the rate of ten miles an hour at a trot, and at the rate of twenty miles at a gallop.

Sleep (Ger. schlaf). That state of the body in which the functions of sensation and volition are suspended, while the vital functions retain their usual activity: the operations of the mind, if not at perfect rest, being disconnected with external objects.

Healthy or natural sleep usually comes on with a peculiar sense of muscular lassitude, gaping, and desire of repose; the eyelids fall, and there is general muscular relaxation. The sense of hearing is that which is longest retained; and we generally hear what is going on about us, and even feel inclined to take occasional part in conversation, long after the eyes are closed.

The quantity of sleep required by different individuals is various, from six to nine hours being the average proportion. Indolent listless persons, and especially those who indulge in the luxuries of the table, and are in good health, will often slumber away from eight to ten hours daily; while others of active dispositions, and who live abstemiously, will be satisfied with four or five hours of sleep: and such persons are generally more disturbed by dreams than the former. Very young children sleep away much of their time, and so also do many old persons. Sleep is often prevented by intense thought, by anxiety, and other mental affections; and also by hunger, and by the application of cold to a part of the body. When a person has been over-fatigued by bodily exertion, sleep is also often courted in vain; and there are many stimuli by which its accession at the usual times is prevented or retarded, such as strong tea, coffee, small doses of opium, and several other articles of medicine and diet. Bodily exercise and mental tranquillity, a full meal, the absence of light, noise, and other disturbing causes, are circumstances generally favourable to sleep; but in all these respects various habits often greatly interfere, and persons accustomed to very active lives when suddenly deprived of their usual occupations often sleep worse than before, indolence becoming an apparent stimulant.

The definition of sleep is still a subject of controversy, some maintaining that we are conscious, others that we are unconscious, while we sleep; while by some it is held that dreams occur during sleep, by others that they occur only between sleeping and waking, i.e. during imperfect sleep. In his treatise *On Sleep*, Sir Henry Holland asserts that 'sleep, in the most general and correct sense of the term, must be regarded not as one single state, but a succession of states in constant variation, this variation consisting not only in the different degrees in which the same sense or faculty is submitted to it, but also in the different proportions in which these several powers are under its influence at the same time.' In his *Physiology of Sleep*, Mr. Arthur Durham says that 'sleep, considered psychologically, may best be defined to be a state in which volition, sensation, and consciousness, are suspended, but can be readily restored on the application of some stimulus.' Considered physiologically, sleep, he thinks, 'may be most correctly regarded as that particular state of cerebral activity, which is essentially associated with the nutrition and repair of the brain substance.' These definitions may appear at first sight opposed to each other, but they may probably be reconciled by the hypothesis that Sir Henry Holland is speaking of actual sleep, while Mr. Durham gives a definition of typical or perfect sleep. Indeed, the conclusions of the latter writer are supported by a series of experiments on the brain of living animals, which seem to establish conclusively the position of Sir H. Holland, that sleep, as it actually occurs in men and other animals, is a succession of ever-varying states.

If sleep be, as undoubtedly it is, a state necessary for the repair of the waste caused by activity of the brain during the hours of wakefulness, the essential conditions of the latter state, when perfect, may be defined to be 'functional activity of the brain, as manifested by sense and intellect, together with destruction of brain substance,' while the corresponding conditions of perfect sleep will be 'rest of the brain (suspension to a greater or less extent of those faculties which are the manifestations of its activity), together with repair and nutrition of brain substance.' Hence, from an anatomical point of view, sleep may be described as 'a state in which the blood-vessels of the brain are occupied by a comparatively small quantity of blood moving at a comparatively slow rate.' That this is actually the case during sleep, all experiments seem conclusively to prove, while they tend further to establish the fact that 'when we are soundly asleep, we do not instantaneously awake to full possession of our faculties; still less do we pass at once from perfect wakefulness into a state of healthy sleep.'

A purely psychological treatment of the subject may be found in M. Alfred Maury's work, *Le Sommeil et les Rêves*. (*Westminster Review*, No. xlix. 'The Physiology of Sleep.')

Sleep-walking. [SOMNAMBULISM.]

Sleeper. In Architecture, a piece of timber whereon are laid the ground joists of a floor. *Sleepers* are also pieces of timber, now rarely used, in foundations, crossed by planks, &c., and at right angles to them, where the soil is bad. Formerly the term was used to denote the valley rafters of a roof.

SLEEPER. [RAILWAYS.]

Sleet (Icelandic sletta, Dan. slud). Snow or hail which is in a partially melted condition

before it reaches the surface of the earth. In some cases sleet may also be produced by the simultaneous precipitation of snow or hail from a superior and of rain from an inferior stratum of the atmosphere. [HAIL; SNOW.]

Sleigh. [SLEDGE.]

Sleight-of-Hand. [CONJURING; LEGERDEMAIN.]

Slewing. In the service of Artillery, turning a gun or mortar on its axis without moving it from the spot on which it rests. The term is also applied to turning a gun or mortar horizontally upon a pivot; this is called *slewing end for end.*

Slices. Wedges of small angle driven immediately before launching under the shores by which the ship is sustained on the shipway. Being driven in simultaneously all round the vessel by blows of hammers, the mass is raised sufficiently to enable the blocks on which the keel has rested to be removed.

Slickenside. A provincial term applied by the Derbyshire miners to Galena or sulphide of lead, which has acquired a smooth and shining striated surface in consequence of the great pressure and friction to which it has been subjected by the dislocation and shifting of the vein. In Geology, the term has a more extended meaning, and is applied to the smooth and polished surfaces which have been produced in any kind of rock by the grinding motion resulting from faults, or fractures and contortions of the beds.

Slide. In Music, a grace used in the German school, and consisting of two small notes moving by degrees.

Slide Rest. A guide employed to carry forward the cutting tool of a turning lathe to the axis of the revolving object. Slide rests of great variety are now used in the arts, and some of them are so contrived as gradually to withdraw the tool as it approaches the middle of the length of the object, so as to turn by self-acting mechanism a rod bulging in the middle.

Slide Valve. A form of valve in which the opening and closing of the orifice is regulated by a sliding plate or plug in the manner of a sluice. One of the earliest examples of the slide valve was the valve of Lavoisier's air-pump, and the slide valve has been applied to feed-pumps, and to pumps of various kinds. Its most common application, however, is to the STEAM ENGINE, to govern the flow of steam to and from the cylinder, its movements being controlled by a moving part of the engine called the *eccentric.*

Sliding Axis. [INSTANTANEOUS SLIDING AXIS.]

Sliding Keel. A narrow oblong board let down at pleasure vertically through the bottom of a small vessel, to serve as a deepening of the keel throughout a portion of her length. Its use is, like that of the leeboard, to sustain the vessel against the lateral force of the wind, and to enable it to bear more sail. At present, the more usual name for this instrument is the *centre-board*, and the boats so fitted are known as *centre-board boats.* The employment of the centre-board is much resorted to in America for small river craft, and in this country for yachts of small burden. It is a great element of safety; and, with its help, boats of draught suited to river navigation may venture into a moderate sea.

Sliding Rule. A mathematical instrument or scale, consisting of two parts, one of which *slides* along the other. As each has certain sets of numbers engraved on it, so arranged that when a given number on the one scale is brought to coincide with a given number on the other, the product or some other function of the two numbers is obtained by inspection. The numbers may be adapted to answer various purposes; but the instrument is chiefly used in gauging, and for the mensuration of timber.

Sliding Scale. In Finance, an attempt to regulate prices by varying the rate of taxation on imports in proportion to the price at which a home produce of the same or a similar kind is offered for sale. Thus, if the soil of a given country grows on ordinary occasions a certain amount of corn, sufficient or nearly sufficient for the subsistence of the people, but which needs for the maintenance of some of its inhabitants, at all times, and in increased quantities in times of scarcity, supplies from foreign countries, the demand for foreign corn will fluctuate according to the exigencies of the market, increasing when the home supply is deficient, decreasing when it is abundant. Now, as the causes which induce a scarcity in one country, even on one kind of soil, are favourable to abundant growth in another country, or even in another kind of soil, the national remedy for occasional dearth in one locality is the compensating plenty of other localities. Such would be, had legislation never interfered with supply and demand in the interest of particular persons, the ordinary course of international trade in agricultural products: and, primâ facie, it would be just as irrational to regulate the corn trade between, say, this country and Russia, as it would be to pass a law, by which a tax should be imposed in wet years on light lands, in the interest of those who grew wheat on heavy soils, or, vice versâ, on heavy lands in dry years, with a view to compensate scanty crops on light soils.

With the purpose, however, of securing a permanent high price for corn, the government of this country proposed, in the year 1814, a sliding scale of charges on which corn could be imported: when the home price was at or under 64*s.* the duty levied was 24*s.*, when at or under 65*s.*, 23*s.*, and so on up till the home price reached 86*s.* at which point the duty was to be 1*s.* This bill failed, but another was brought forward in the following year fixing the maximum at 80*s.*, and, notwithstanding strenuous opposition, the bill passed. Similar Acts, the details of which may be found in Mr. M'Culloch's account of the corn laws and corn trade, printed with the appendix to his edition of Adam Smith, were passed up to the date of their abolition.

The sliding scale totally failed in effecting its purpose. Its adoption was due, it may be asserted, to gross ignorance of the doctrine of prices. The canon now thoroughly understood, but then only imperfectly apprehended, is that the prices of the necessaries of life rise in a geometrical ratio with scarcity, to an unlimited amount, and fall in the same ratio as the occurrence of plenty to a limited amount. There is no check to the exaltation of prices in times of famine, until of course population perishes; but, in times of excessive plenty, the limit, though low, is seldom transgressed, because the agriculturist or corn merchant is impelled to retain his stock in hopes of a better market, and because (to some extent, at least) a period of low prices in the necessaries of life is generally accompanied by an inward demand for what may be called the secondary or subordinate products of agriculture, such as meat, butter, cheese, and the like. Now, as under the operations of the sliding scale, the foreign supply was uncertain, because the demand was excessively fluctuating (though considerable quantities of corn were stored in bond), the price of home produce varied extremely, falling sometimes so low that the farmer, who was forced by this artificial system to depend mainly on wheat prices, was unable to fulfil his obligations to his landlord, and rising sometimes so high as to put the greatest distress on the mass of the people. Further, as soon as the price reached the point at which corn could be imported duty free, the country was flooded with foreign corn, and the reaction was excessive. The sliding scale appeared to confer a boon on the agriculturist; in effect it inflicted a lasting injury, because it increased the range over which prices varied, the worst condition in which producer and consumer could be placed. Nothing was more common, and nothing indeed was more natural, than the complaints of agricultural distress which were uttered during the maintenance of the corn laws and sliding scale—complaints which have been silenced by those measures of reform which landlords and farmers predicted would be their ruin, but which have, on the contrary, been their preservation.

A regulation analogous to a sliding scale is at the present time operative on banking credit. By a series of causes, some of which have arisen naturally, some from legislative arrangement, the issue of paper credit, in the form of Bank notes, is practically confined to one establishment—the bank of England. Under certain circumstances, the demand for banking credit, for the purposes of absolutely legitimate trade, rises and falls considerably; and as this banking credit, in mercantile transactions, is as essential to commercial existence as food is to population, so in times when the demand is excessive any hindrance of supply precipitates and intensifies a period of commercial panic, i.e. a state when paper credit is undoubtedly high, but commercial credit is temporarily low. In this crisis, the Bank Act restricts the issue of paper and thus checks accommodation, operating exactly as the sliding scale did on corn, with this important difference, that as the corn law was relaxed, when famine was imminent, the Bank Act is stringent only when the necessities of the position demand an enlargement of credit.

Sliding Ways. In Shipbuilding, two narrow inclined planes built strongly on the shipway, and intended to form the tracks by which the cradle sustaining the vessel glides into the water.

Sling (Ger. schlinge). A weapon made of a strap and two strings, by means of which a stone or other missile is projected with much greater velocity than could be given to it by the hand without such assistance. The velocity with which the projectile is discharged is the same as that with which it is whirled round in a circle having the string for its radius, and may therefore be computed when the time of revolution and the length of the string are given. The sling was known as a weapon of offence in the earliest ages.

Sling Cart. In the service of Artillery, a two-wheeled carriage for transporting ordnance through short distances. A *sling waggon* has four wheels, and is used for longer distances.

Slings. On Shipboard, combinations of rope for hoisting horses, casks, or goods, in or out of the vessel. Also ropes or chains by which yards are suspended in their places to the relief of the lifts.

Slip. In a dockyard, an inclined plane having an inclination to the horizon of about 1 in 19, laid upon a most solid foundation, and serving as the base on which a ship is built, and from which, by its slope, the vessel is run into the water when finished. Repairing slips are now furnished with carriages on many wheels and rails, which are run under ships as they float at high tide, so that when the ebbing water has grounded the vessels on the trucks, they can be hauled up by steam power high and dry for examination or repairs.

Slip Stoppers. On Shipboard, apparatus for suddenly letting the anchor go out of its lashings and fishings, when it is required to drop it.

Slips. In Printing, where from the nature of the work, great alterations and corrections are made in the proofs, they are occasionally printed on slips of paper. This gives facility to an author or editor to add or take away matter without overrunning or remaking up.

Sloam (probably akin to *loam*, as *slime* to the Latin limus, *mud*). Layers of clay between those of coal.

Sloanea (after Sir Hans Sloane). A tropical American genus of *Tiliaceæ*, consisting of trees often upwards of a hundred feet high, the wood of many of them being extremely hard and difficult to work; that of *S. jamaicensis* is known in Jamaica as Breakaxe and Ironwood.

Sloanite. A hydrated silicate of alumina, lime, and magnesia, found in white radiating masses, in the gabbro rosso of Tuscany. It is named after Mr. Henry Sloane.

Sloe (A.-Sax. sla, Ger. schlehe). The

name of one of our wild Plums, *Prunus spinosa*, remarkable for the austere flavour of its fruit.

Sloke. Another name for Laver, which is prepared from the common *Porphyra vulgaris* and *P. laciniata*. Green Sloke is a name given in Scotland to several species of *Ulva*, which are also called Oystergreen.

Sloop (Dutch sloep, Fr. chaloupe). A vessel with one mast like a cutter; but having a jib stay, which a cutter has not. Also the general name for ships of war below the size of corvettes, and above that of brigs.

Slope. In Geometry, angular departure from a horizontal direction. The *lines of greatest slope* on any surface cut at right angles the *lines of level*. If $u=0$ be the equation to any surface, referred to rectangular co-ordinates, then the plane of (x,y) being horizontal the equations of the projections upon it of the lines of level will be formed by putting $z=c$, a constant, and the differential equation of these lines will be

$$\frac{du}{dx}dx+\frac{du}{dy}dy=0;$$

consequently the differential equation of the projections of the lines of greatest slope will be

$$\frac{du}{dx}dy-\frac{du}{dy}dx=0.$$

Slops. Clothes and bedding supplied from the ship's stores to the seamen, but at their expense.

Slotting Machine. A machine in which a tool moves vertically, in the manner of a mortising chisel, so as to cut out slots or mortises, or to pare round the edge of any object requiring to be made fair and smooth on the edge. Slotting machines were originally constructed for cutting key-seats in toothed wheels; but they are now used for a great variety of purposes.

Slough (A.-Sax. slog). A Surgical term applied to the separation which ensues between dead and living parts.

Slow Match. [MATCH.]

Slue. In Naval language, *to slue* is to turn a cylindrical piece of timber, as a mast or boom, about its axis, without moving it out of its place.

Sluice (Dutch sluis, Ger. schleuse, from schliessen, *to close*). In Hydraulics, a frame of timber, stone, or other solid substance, serving to retain and raise the water of a river or canal, and, when necessary, to give it vent.

Slur. In Music, an arch ⌒ connecting two or more notes not on the same degree, indicating to the performer that in playing they are to be united as much as possible.

Smack (Dutch smak-schip). A small decked or half-decked vessel, of various rig, used principally in the fishing trade and by pilots.

Smalcald, League of. [REFORMATION.]

Small Arms. Under this name are included all those hand fire-arms which do not come under the head of *ordnance*; as muskets, carbines, and pistols. There are now (1866) in the British service 32 different small arms, all of which, with one exception (naval smooth-bored pistol), are rifled. The table on the next page describes the most important of these arms.

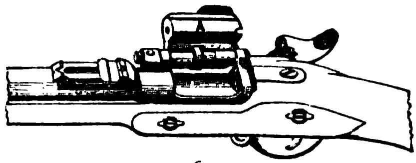
In addition to the seventeen arms described in the table, there are four others still in the service, which are being superseded; and eleven for Indian service only, completing the total number of thirty-two.

As regards the systems of rifling in the service arms, the Whitworth rifle has an hexagonal, the Westley Richards' carbine an octagonal, the Lancaster carbine an elliptical bore. The rifling of the Enfield rifle is simple, and much like the Woolwich system employed for ordnance. The Sharp carbine is rifled on this system with three grooves.

It has been decided to supersede the present muzzle-loading arms by breech-loaders; and for this purpose various inventors and gun-makers were invited to send in patterns for converting the present service Enfield rifles into breech-loaders. It is impossible, in the limits of this article, to enter into the various systems for closing the breech. The chief competitors were Messrs. Westley Richards, Green, Mont Storm, Joslyn, Shepard, Wilson, Snider, Henry, and Lindner. The system of Mr. Snider, in which the cartridge contains within itself its principle of ignition, has been selected. The great advantage which a cartridge of this nature possesses is that it does away with the necessity for fixing a cap when loading, which always occupies some time, and in cold weather is a difficult operation.

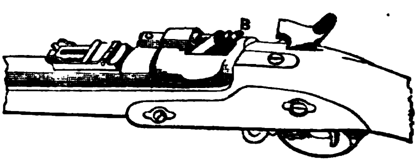
The Snider converted Enfield (figs. 1 and 2),

Fig. 1.



Open.

Fig. 2.



Closed.

Snider's Converted Enfield.

which has been improved by the patentee in conjunction with the superintendent of the government small-arms factory at Enfield, appears to be a simple and safe weapon, little liable to get out of order. It is also a cheap weapon, the cost of conversion being only about 15*s*. for each rifle. The method of conversion

Service for which intended	Description of Arm	Musket: Weight lb	Musket: Weight oz.	Musket: Length ft.	Musket: Length in.	Bayonet or Sword: Weight lb.	Bayonet or Sword: Weight oz.	Bayonet or Sword: Length beyond muzzle ft.	Bayonet or Sword: Length beyond muzzle in.	Diameter of bore at muzzle, inches	Number of grooves Progressive or Uniform	Twist in inches	Yards up to which arm is sighted	Remarks
Cavalry	Cavalry rifle carbine, pattern '61 .	6	11	3	0¾	..	..	..	..	·577	5 P	1 in 48	600	
Cavalry	Westley Richards' breech-loading carbine	6	8	2	11⅞	..	..	..	..	·451	8 U	1 in 20	800	25,000 ordered to be adopted in place of above '61 pattern.
Cavalry	Sharp's do. do.	7	7	2	11½	..	..	..	..	·551	3 U	1 in 48	600	Issued to cavalry in India and dépôts at home.
Cavalry	Terry's do. do.	6	3½	3	1⅞	..	..	..	..	·539	5 U	1 in 36	500	Issued to 10th Hussars.
Cavalry	Cavalry rifle pistol 8-inch, '59 . . .	2	10½	1	2	..	..	..	..	·577	5 P	1 in 48	100	For Lancers, and troop serjeant-majors and trumpeters of all regiments.
Artillery	Royal Artillery rifle carbine, pattern '61	7	8	3	4½	1	12	1	10¾	·577	5 P	1 in 48	600	
Engineers	Royal Engineers' rifle carbine, Lancaster	7	6½	3	11½	1	10½	2	0	·577	Oval	Variable	1000	
Infantry	Long Enfield rifle, pattern '53 . . .	8	14½	4	6	0	13½	1	5½	·577	3 P	1 in 78	1000	For infantry generally.
Infantry	Short do. do. '56	8	2½	4	0½	1	12	1	10¾	·577	3 P	1 in 78	1100	For all serjeants, and rank and file of Rifle Brigade and 60th Rifles.
Infantry	do. do. do. '60	8	8½	4	0½	1	11½	1	10¾	·577	5 P	1 in 48	1250	
Infantry	Whitworth rifle, pattern '62 . . .	9	13½	4	8½	0	13½	1	5½	·451	6 U	1 in 20	1250	1,000 issued for experiment.
Infantry	Do. short rifle, pattern '63 . . .	9	14	4	0½	1	11¾	1	10¾	·451	6 U	1 in 20	1350	8,000 issued to Rifle Brigade and 60th Rifles for experiment.
Navy	Naval rifle, pattern '58	8	8	4	0½	2	6	2	2⅞	·577	5 P	1 in 48	1250	For all sailors, with a cutlass sword-bayonet; and for marine artillery with artillery sword-bayonet.
Navy	Deane and Adams' revolver pistol, 54 gauge	2	6½	1	8	..	..	..	..	·434	3 U	1 in 20	No Sight	Issued to ships.
Navy	Colt's do. 34 gauge	2	9½	1	1⅞	..	..	..	..	·358	7 P	1 in 36	do.	
Navy	Deane and Adams' do. 38 gauge . .	4	7½	1	11⅝	..	..	..	..	·470	3 U	1 in 18	do.	For Coast Guard only.
Navy	Naval smooth-bore pistol	2	3½	0	11⅝	..	..	..	..	·570	..	..	do.	

is as follows: about two inches of the Enfield barrel are cut away at the breech, and a solid breech-stopper, A, working sideways on a hinge, is placed in the opening thus made. Through this stopper passes a piston, one end of which, B, when the breech is closed, receives the blow from the hammer, while the other communicates it to the centre of the cartridge, thus firing the latter. There is an arrangement for withdrawing the old cartridge case after each discharge, by means of sliding back the stopper on the bar on which it hinges, when a mere tilting action of the hand throws out the old case, and the new one can be inserted. With the cartridge described in SMALL-ARM AMMUNITION there is no escape of gas, and the accuracy of the arm is about 33 per cent. greater than that of the muzzle-loading Enfield with its ordinary service cartridge. As many as 15 rounds have been fired from it in a minute, showing a rapidity of fire more than five times as great as that of the unconverted arm. It is remarkably free from fouling, and little liable to deterioration by bad weather.

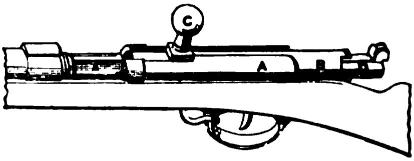
On comparing it with the Prussian needle-gun, its advantages are at once apparent. It is much simpler in construction, and lighter, weighing only 9 lbs. 5½ oz., while the needle-gun weighs 10 lbs. 11 oz.; the latter arm also cannot be fired so rapidly.

The success of the needle-gun in the campaign of Bohemia is not to be attributed to any peculiar advantages of that form of breech-loader, but to the vast superiority of any safe breech-loading small arm with cartridges containing their own principle of ignition over any muzzle-loading arm requiring to be capped.

The construction is complicated, but may be thus roughly stated. At the breech end of the barrel is an open channel A, in which slides an iron tube B, with a handle C. This tube is pierced in front with a small hole, through which the needle passes to ignite the cartridge. The needle is a thin steel wire about $\frac{8}{100}$ inch

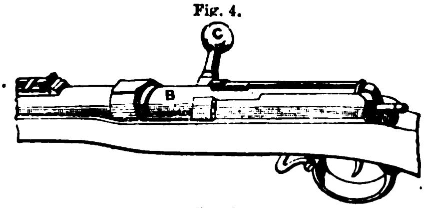
in diameter, bluntly pointed, and is carried in a small tube D in the rear part of the iron tube B. The tube B is capable of being moved backwards and forwards by means of its handle C, which passes through a perforation in the barrel like a bayonet notch. When the tube is drawn back as far as it can go, an open chamber is left between it and the barrel (as in fig. 3). The needle is drawn back

Fig. 3.



Open.

Fig. 4.



Closed.

Prussian Needle-gun.

with and by the tube D, forces back a spring, and becomes fixed by the trigger catch. The cartridge is now introduced into the chamber, and the tube B is pressed forward till its end is in contact with the rear of the barrel; the handle is turned round in the notch, and the breech is closed (as in fig. 4), the needle remaining fixed behind. When the trigger is pulled, the needle is released, and the spring drives it forward into the cartridge, igniting the detonating composition.

The barrel is rifled with four grooves, having a uniform twist of one turn in forty-two inches. The cartridge is described in SMALL-ARM AMMUNITION.

Swords, lances, cutlasses, boarding pikes, and boarding axes, are sometimes called *small arms*.

Small Wares. A commercial term applied to tape, bindings, braid, and other textile articles of that kind.

Small-arm Ammunition. The most important bullets used in our service are: 1. The general service Enfield rifle bullet. [BULLET.] 2. The Whitworth bullet, used with the Whitworth rifle; its length is 1·292 inches, diameter ·442 inches, weight 480 grains; it has a hollow in the base without cap or plug. 3. The Westley Richards bullet, made of lead with five per cent. of tin; it has no hollow in the base, but a belt round the hinder part. 4. Metford's percussion bullet; this is merely an ordinary Enfield bullet, having a chamber down its longer axis, to within one-fifth of an inch of the hollow; this chamber contains four and a half grains of detonating composition; and the bottom is closed with wax. It is intended to explode ammunition waggons.

The cartridges for the Enfield rifle are made in two ways, and called either *rolled* or *bag* cartridges; the former is made of four pieces of paper, the first two forming the powder cylinder; in the bag-cartridge the powder cylinder is made from the pulp; the third paper contains the bullet, and laps over the powder cylinder; the fourth paper joins bullet and powder cylinders together. These cartridges are white. Blank cartridges are made of purple paper, and contain powder only.

Percussion caps have already been described. [PERCUSSION CAP.]

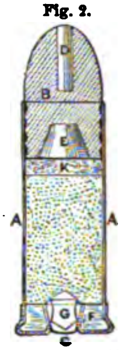
In most breech-loading arms, the detonating composition which ignites the cartridges is contained in the cartridge itself. *Side-fire* cartridges are those in which this is ignited by a blow on the side of the cartridge. *Central-fire* cartridges are ignited by a blow on the centre, and to this class belong the Prussian needle-gun and Snider's converted Enfield, which latter is now adopted in the British army.

Fig. 1.

Cartridge for Needle-gun.

A. Compressed paper cylinder.
B. Bullet.
C. Cavity containing detonating composition.
D. Charge of powder.

Fig. 2.



Cartridge for Snider's Converted Enfield.

A. Cartridge-case (thin rolled brass sheeting).
B. Bullet. C. Cap.
D. Wooden plug.
E. Clay plug. F. Papier mâché. G. Anvil.
K. Cotton wool.

In the cartridge of the Prussian needle-gun, the bullet B is separated from the powder D by a rolled and compressed paper cylinder A, which is hollowed at the end next the bullet. It has a cavity at C, in which is lodged in front of the powder the fulminating composition to be exploded by the thrust of the needle, which pierces through the powder. The bullet is ogival in form, weighs 487 grains, and is fired with a charge of 75 grains of powder; it has no hollow at the base, and does not expand into the grooves of the piece when fired, but the paper cylinder enters the grooves and imparts the requisite rotation to the bullet.

The cartridge for Snider's converted Enfield, as designed by Colonel Boxer, appears to be the best yet produced. The case A is made of thin sheet brass, rolled into a hollow cylinder, one end of which receives the bullet B, the

other end fitting into the metallic cap C, which contains the percussion or ignition arrangement of the ordinary central-fire nature. The brass case, which is covered with thin paper, uncoils on discharge, and contracts to a slight extent when relieved from the internal pressure of the gas, thus guarding against splitting and escape of gas in the first instance, and facilitating withdrawal in the second. The bullet is externally similar to the Enfield bullet, but has a chamber, as in Metford's bullet, down the axis. This is filled by a wooden plug D; the bullet being thus made lighter than the ordinary Enfield bullet, and the centre of gravity being thrown further back, which improves the shooting. The bullet has also some grooves or cannelures round its base end, which contain the lubricating bees-wax. There is the usual clay plug E, and some cotton wool K, between the powder and the bullet.

These cartridges have been most severely tested; they resist damp to an extraordinary extent, far beyond any probable requirements of a campaign; they are remarkably safe against premature or accidental explosion, while there were only three misfires out of several thousand trial rounds, and those from causes which can be guarded against, while the expense is not much greater than that of the old Enfield cartridge. [SMALL ARMS.]

Smallpica. In Printing, the name of a kind of type three sizes larger than that used in this work. There are at the present day a greater number of books printed in this type than in any other. [TYPE.]

Smallpox. Called also *Variola*, because it changes and disfigures the skin. There are two forms of this disease, generally called by medical men the *distinct* and the *confluent*; in the former the pustules are separate, in the latter they coalesce. *Distinct smallpox* begins with the usual symptoms of inflammatory fever; i.e. pains in the back and loins, sickness, drowsiness, headache, pain upon pressure about the region of the stomach, and in infants one or more epileptic fits. About the end of the third day little red spots, much resembling flea-bites, make their appearance upon the face and head, which spread during the fourth day over the breast, body, and limbs; about the fifth day a circular vesicle forms upon each little point, depressed in the centre, surrounded by an inflamed margin, and containing a colourless fluid, and at this time the eruptive fever disappears; about the sixth day the throat becomes sore, and the saliva viscid; and about the eighth day the face is swollen, and the pustules round, prominent, and prevalent; about the eleventh day the pustules attain their full size (about that of a pea), and the matter which they contain becomes opaque and yellow, and a dark central spot appears on each; the swelling of the face subsides, and is transferred to the hands and feet, and more or less secondary fever now ensues. After this, the pustules become rough, break, and scab over, and a dark brown spot remains for some days; and if the pustules have been large an indentation is left; the remaining symptoms gradually subside, and about the seventeenth or eighteenth day the secondary fever disappears.

Confluent smallpox is ushered in by a fever of a far more violent and threatening character; all the incipient symptoms are aggravated; delirium or coma may attend them: and in infants there is diarrhœa, and in adults salivation. The eruption is very irregular in its progress and appearance, and usually preceded by red patches upon the face, from which the pustules emerge on the second day in the form of clusters somewhat resembling measles. Their progress is rapid; but instead of being circular and well defined, they are flat and irregular in shape, and contain a brownish fluid quite unlike pus: the intermediate species between the clusters are generally pale and flaccid. The tumefaction of the face and running of saliva are greater than in the distinct spaces; and the fever does not cease upon the appearance of the eruption, but about the ninth day it generally becomes aggravated, the eruption livid and accompanied by the petechiæ or purple spots; and about the eleventh day from the commencement of the disease it often terminates fatally.

This disease is the effect of a specific contagion, and is produced either by inoculation, or by exposure to the effluvia from persons suffering under it: in the latter case it is usually called the *natural smallpox*. When the distinct smallpox goes regularly through the stages above described it is rarely dangerous, except from mismanagement; but it often leaves a tendency to inflammatory disorders, and in a scrofulous habit it excites that disorder into activity. Any of the symptoms which have just been described as characterising confluent smallpox are alarming; so is a sudden disappearance of the eruption, or change in its appearance, followed by depression or delirium. In treating the distinct smallpox, the febrile symptoms are to be moderated by cool air, saline and mild acid diluting drinks, and very gentle aperients. Bleeding and purging are in almost all cases to be decidedly avoided. Great irritability may occasionally be allayed by small doses of opium and camphor, or, what is preferable, by muriate of morphia: this will also check diarrhœa, should it supervene. The confluent form generally requires more or less of the treatment which is adopted in low or putrid fever. Obstinate vomiting, which is sometimes not only a troublesome but alarming symptom, is best encountered by the saline draught in the act of effervescence, with a few grains of aromatic confection, and a few drops of tincture of opium.

Smalt (Dutch smelten). A fine blue colour used in painting and printing upon earthenware, and applied to several other purposes in the arts. The finest smalt is made by fusing glass with oxide of cobalt, by which a very deep blue compound is obtained, which when finely powdered acquires a beautiful azure colour.

Common smalts are prepared by fusing mixtures of zaffre, sand, and pearlash.

Smaltine. One of the most important ores of cobalt, being (with Cobaltine) that from which most of the smalts of commerce is manufactured; whence the name. It is an arsenide of Cobalt, composed of 72 per cent. of arsenic, 95 cobalt, 9 iron, and 9·5 nickel. It is found in Cornwall and Cumberland; in Scotland, &c.

The arsenides of cobalt only are, strictly speaking, included under the term *Smaltine*; those varieties which contain Nickel being called *Chloanthite*. [Chathamite.]

Smaragd (Gr. σμάραγδος). In modern times this word is used as a synonym of *emerald*; but it was applied by the ancients to various other precious stones, such as fluor spar, green vitrified lava, green jasper, and green glass. The passage of Pliny (*Nat. Hist.* xxxvii. 5), in which Nero is said to have been in the habit of viewing the gladiatorial combats *in a smaragd*, is generally understood to signify a smooth polished mirror made of some of the above substances; but it has been maintained that the emperor was short-sighted, and used a concave eyeglass formed of the smaragd. The smaragd is found in various parts of Europe, Asia, and America; but particularly in the Ural mountains, and in the mines of Chili and Mexico. [Emerald.]

Smaragdite (Gr. σμάραγδος). A peculiar laminated form of Augite or Hornblende, of a bright emerald-green colour. It is found in Switzerland, at Monte Nova and near Geneva; also in Corsica, in Felspar.

Smart Money. The Military term for the fine to be paid, in order to escape prosecution, by a recruit who has accepted enlisting money, but refuses to be attested.

Smart Ticket. A certificate of a seaman's having received a wound or hurt.

Smectite (Gr. σμηκτός, *smeared*). A greenish kind of Halloysite from Condé in France.

Smectymnuus. A work against episcopacy, in reply to Bishop Hall, was published shortly after the assembling of the Long Parliament under this title, which was obtained by clubbing together the initials of the names of the five authors, Stephen Marshall, Edward Calamy, Thomas Young, Matthew Newcomen, and William Spurstow. This book was followed by a long and vehement controversy, in which Milton took part in reply to the rejoinders of Archbishop Usher.

Smelite (Gr. σμήλη, *soap*). A kind of Kaolin (China Clay), found near Telkebanya in Hungary.

Smell. This sense resides in the mucous or pituitary membrane which lines the nostrils, and the surface of which is more or less convoluted or extended in various orders of animals. In the human subject this membrane is highly vascular, and largely supplied, especially in its upper parts, with nervous filaments, or ramifications of the olfactory trunk, which has its origin, by three distinct roots, from the posterior, inferior, and internal parts of the anterior lobe of the brain, and proceeding towards the perforated plate of the ethmoid bone, divides into the small threads just mentioned.

The physiology of odours is a curious and intricate subject, requiring much more experimental investigation than it has hitherto received. The air is the great vehicle by which their various influences are transmitted in the act of inspiring to the olfactory surfaces, and for the diffusion of most odours a certain degree of humidity in the air appears absolutely essential. There is scarcely any sense the degree of perfection of which varies so much in different individuals as that of smell, some being painfully alive to those odorous influences which are not even perceived by others. An obtuseness of this sense is also very frequent, and its almost entire absence by no means uncommon; this is especially the case in certain catarrhal complaints, and in some other affections of the lining membrane of the nose.

Smelt (A.-Sax.). A delicate small fish, of the Salmonoid family (*Salmo eperlanus*, Linn.), separated as a genus (*Osmerus*, Cuv.) by having a transverse row of vomerine teeth, and a row of conical teeth along the palatine and pterygoid bones. The tongue has strong teeth anteriorly and longitudinal rows of small teeth behind. Scales of moderate size; pseudo-branchiæ rudimental; pyloric appendages few and short. The *Osmerus eperlanus* frequents the coasts and numerous fresh waters of Northern and Central Europe.

Smew. The name of the diver called *Mergus albellus* by Linnæus. [Mergus.]

Smilaceæ (Smilax, one of the genera). A small natural order of Endogenous plants with weak or twining stems and reticulated leaves, not distinguishable from those of Exogens. Lindley refers them to a class which he calls Dictyogens, and distinguishes them by their bisexual or polygamous hexapetaloideous flowers, their several consolidated carpels, and their axile placentæ. The drug called Sarsaparilla, or Sarza, is the root of various species inhabiting South America, and is held in high esteem for its diuretic, demulcent, alterative qualities. They are found especially in the temperate and tropical parts of Asia and America.

Smilacine (Gr. σμῖλαξ). A crystalline principle obtained from Sarsaparilla root.

Smilax (Gr.). An extensive genus of Dictyogens, giving its name to the order *Smilaceæ*, and consisting of climbing shrubs, natives of the warmer, temperate, and tropical regions of both hemispheres. Some of the species furnish the drug known as Sarsaparilla, so called from the Spanish sarza, *bramble*, and parilla, *a vine*, in reference to the thorny stems of the plants.

The Sarsaparilla of the shops consists of the roots, to which are attached portions of the rootstocks, of various species of this genus. It is by no means clearly ascertained what are the exact species yielding the varieties of this drug met with in commerce, but it is sup-

posed to be the produce of *S. officinalis*, *S. medica*, and *S. papyracea*, while other species are mentioned as occasionally used. The species named *S. Sarsaparilla*, which is common in the United States, does not appear to be used medicinally, notwithstanding its name. In commerce, the various kinds of Sarsaparilla are divided into two principal groups, according to the quantity of starchy material which they contain. The mealy Sarsaparillas contain an abundance of farinaceous matter in the inner part of the rind. To this group belong Caraccas Sarsaparilla, the produce probably of *S. officinalis* or *S. syphilitica*; Brazilian Sarsaparilla, which is imported in cylindrical bundles, and is considered to consist of the roots of *S. papyracea* and *S. officinalis*; and Honduras Sarsaparilla, the botanical origin of which is quite unknown. The non-mealy Sarsaparillas are known as Jamaica or Red-bearded Sarsaparilla, which is imported into Jamaica from Columbia, and is probably the produce of *S. officinalis*; Lima Sarsaparilla, which consists of roots, imported not only from Lima but from Costa Rica, and of which *S. officinalis* is supposed likewise to be the source; and Vera Cruz Sarsaparilla, the produce of *S. medica*.

Smithsonite. Hydrated silicate of zinc, composed of 67·4 per cent. of oxide of zinc, 25·1 silica, and 7·5 water. It occurs in colourless rhombic prisms; also stalactitic, botryoidal, granular, and compact; sometimes it is of grey, blue, yellow, green or brown shades, and varies from transparent to opaque. It has a vitreous lustre, is brittle, and becomes phosphorescent when rubbed, and electric by heat. It is found in Cumberland, Derbyshire, and in the Mendip Hills in Somersetshire. Named after the chemist Smithson, by whom it was analysed. The name Smithsonite has also been applied by some mineralogists to Calamine or Carbonate of Zinc.

Smoke (A.-Sax. smoca, Ger. schmauch, akin to Gr. σμύχω, σμώχω). Smoke has been defined as the visible effluvium or sensible exhalation of anything burning. The term is commonly applied to those results of the combustion or ignition of pit-coal which escape from chimneys, and which constitute a serious and well-known evil and nuisance in large towns, manufacturing districts, and almost everywhere where large quantities of coal are consumed. Coal is often a very complex substance; but putting aside its occasional and adventitious ingredients, carbon, hydrogen, nitrogen, and oxygen may be regarded as its ordinary and essential constituents; and the results of its *perfect* combustion would therefore be carbonic acid steam and nitrogen. These substances would constitute invisible and incombustible gases and vapour, and would therefore escape from the chimney top, and blend with the atmosphere, without being perceived. But it unfortunately happens that from the way in which coal is burnt its combustion is far from being perfect, and that besides the above-mentioned products inflammable gases and vapours, together with large quantities of very finely divided carbon, constituting soot, and black and brown smoke, are vomited forth from the chimney shaft, not only contaminating the air, but also occasioning loss of fuel.

There are many practical difficulties in the way of burning smoke, but experience has shown that none of these are of such a nature or magnitude that they may not be overcome by perseverance and skill. They all merge into one common principle, that of mixing air with the combustible vapours and gases generated by the action of heat on pit-coal, so that by virtue of a due supply of oxygen they may be made to burn with flame, and become entirely converted into incombustible and transparent invisible vapours and gases, instead of being, as they now are, only partially burned, their carbon being precipitated, and escaping, together with the other imperfectly consumed matters, into the air.

But to carry out that object a high temperature must be maintained within the furnace; and it is consequently easier to burn the smoke in metallurgic furnaces where it comes into contact with red hot surfaces, than in the furnaces of steam boilers where it is rapidly cooled by the surrounding water. And not only is air and heat necessary to burn smoke, but an adequate time for the operation must be afforded. To this end, combustion chambers are now generally constructed behind the furnace, and fire tiles are interposed either at the bridge of the furnace or at some other suitable part, where they will be intensely heated so as to compel the mixture of smoke and air to encounter hot surfaces before it is cooled very much by entering the flues. The nuisance of smoke has been materially aggravated of late years by the use of coal instead of coke in locomotives, and most of the expedients employed in them to burn the smoke are quite ineffectual. In common land boilers, where slow combustion can be maintained, the smoke will be effectually burnt if the coal is first placed on a dead plate at the mouth of the furnace, where it will be coked, and the gases will be burned by passing over the fire. This, however, involves two operations in stoking, viz. that of pushing back the coked coal upon the fire and of refilling the dead plate with a fresh supply of raw coal. By the use of the revolving grate, however, this labour may be saved, as in that arrangement the coal is constantly precipitated by suitable apparatus on the part of the grate near the door, and the smoke passing from it over the incandescent fuel on the bars is burnt, while by the time the gases have been all expelled, the revolution of the grate will have carried it to the part of the furnace farthest removed from the door, where it will in its turn promote the combustion of the gases proceeding from the coal last introduced. These plans, however, are hardly applicable to marine, and not at all applicable to locomotive boilers. But in all furnaces in which there is a good draught (and in locomotive furnaces the draught is very great) the

smoke may be effectually burnt by making it pass through the fire. This may be accomplished by placing the fire between vertical bars through which the air enters, and vertical tubes through which water circulates, and past and among which the smoke has to proceed in its way to the chimney. By keeping the outside solid bars sufficiently long, and the inside tubular bars sufficiently short, the smoke will have to descend for a certain distance through the fire before it can escape; and it will thereby be completely consumed. The smoke from houses may be entirely avoided by the use of coke or Welsh coal instead of bituminous coal; such fuels occasion a little more trouble in the lighting of fires, but they are otherwise much better adapted for domestic purposes than bituminous coal. The laws against smoking furnaces should be rigidly enforced, and effectual means for obviating the nuisance will then be quickly adopted.

Smoke Ball. In Artillery, a paper shell filled with a composition which, when ignited, emits volumes of smoke. It is thrown into mines or other confined situations to suffocate an enemy's working parties; and has been used as a signal in the arctic regions.

Smoke Quartz or **Smoky Quartz.** A variety of Rock Crystal with a smoke-brown coloured tint, found in Scotland, Bohemia, Nova Scotia, &c. The transparent wine-yellow and clove-brown crystals which are the true Cairngorm, are included under this variety, as are also the False Topaz, Morion, Topazine Quartz, &c.

Smoke Sail. A small sail hoisted before the funnel of the galley, when the ship is at anchor head to wind, to screen the quarter deck from the smoke.

Smoke Stack. In a steam-vessel, the funnels and steam-pipes rising from the flues and boilers above the deck. In ships of war, they are commonly telescopic, to be drawn down out of shot in time of action.

Smorzato (Ital. extinguished). In Music, a term denoting that the violin bow is to be drawn to its full extent, but gradually lighter till the sound is nearly lost.

Smuggling (Dutch smokkelen). The offence of privately importing or exporting goods, the importation or exportation of which is either prohibited or loaded with heavy duties. Thus, before the Bank Act of 1819, the exportation of British gold coin was an offence against numerous statutes and the received canons of monetary policy; and at all times when the legislature has imposed a tax on articles of foreign produce, the attempt to introduce privately such articles either for consumption or sale, is an offence against the revenue, by which the honest consumer, who has half paid the tax, is defrauded. Such acts are called smuggling. Analogous to them are frauds on the excise, i.e. on internal taxes, as contrasted with those which are levied at the ports, or in the act of taking goods out of bonded warehouses. For obvious reasons, frauds on the excise are far less common than frauds on the customs; except in the case of illicit distillation, and perhaps in the manufacture of malt.

The tendency to smuggle foreign goods on which duties are ordinarily and legally payable is generally to be traced to the folly of governments, to the demand for articles on which excessive customs duties are levied, and to the sympathy and co-operation of such as are debarred from the use of these articles with the persons by whom their needs are unlawfully supplied. It is not the case, it may be confidently asserted, that high duties levied for the intelligible needs of government are necessarily provocative of smuggling, for very heavy taxes may be and are payable from many articles without this consequence; thus, the tax on tobacco is far in excess of its value, and if the community were bent on enjoying this luxury by unlawful means, it does not seem likely that any preventive service could effectually check its illegal importation; but the community acquiesces in the tax, and public opinion is, on the whole, hostile to those who attempt to evade the legal obligation of paying a customs debt. The decline of the practice, once common enough, of smuggling tobacco, is, we may be convinced, due quite as much to the force of a judgment on the part of the people, endorsing the equity of the law, as it is to any regulations and precautions on the part of the custom house and of its officers.

The case is very different when a tax is levied either to sustain a particular interest in the community, or when government attempts to enforce certain sumptuary laws on the public, or when there is a general impression that the tax is levied in defiance of equity or expediency. Thus, in the old days of the East India Company's trading monopoly, the smuggling of tea was a regular and acknowledged branch of business; during the existence of the Gin Act, when an attempt was made to force abstinence on the people by means of a prohibitory excise and customs duty, private stills were universal, and smuggling excessively common; and when the law forbad the exportation of coin, the most respectable houses were engaged in an illicit trade in melted sovereigns or guineas.

An abolition of restrictions on trade in the first case, an abandonment of the affectation on the part of government of inculcating personal morality by the machinery of a police force, and such a course of fiscal arrangements as induces the public to recognise in the impositions of customs and excise duties a mere intention of procuring a necessary revenue in the easiest and least oppressive way, are fatal to the practice of smuggling, not so much, probably, because the temptation to smuggle is taken away, but because sympathy with and encouragement of the smuggler cease. The smuggler is no longer the agent by whom oppressive laws may be evaded, and impertinent interference avoided, but a mere rogue who commits at once a fraud on the public purse and a wrong on the honest dealer.

The tendency towards smuggling has been indirectly stimulated in no slight degree by the policy of government. While all administrations attempt to coerce by very energetic measures any frauds on their own revenue by means of illicit trade or illicit productions, they have been by no means equally sensitive to the duty of checking frauds on the revenue of neighbouring nations, and in many cases have treated such frauds as a matter of the highest public policy. Thus, the Spanish government, either from falling into the common delusion of the protectionist theory, or in retaliation for the action of our government, having put prohibitive duties on English goods, the British government recognised that the chief value of Gibraltar lay in the convenience which it afforded for a smuggling trade, and diligently furthered this trade. So, again, during the time in which the first Napoleon attempted, by his insane and suicidal Berlin and Milan decrees, to check or even destroy the exportation of British produce to all parts of the Continent over which his authority or influence extended, and enforced his decrees by inflicting the most sanguinary punishments on offenders against these regulations, the British government encouraged smuggling by every means in its power, and occupied several islands in which to store its produce, and from which to evade the decrees in question. It is very hard, however, for a government to induce a belief in the immorality of an action which it treats as a high crime and misdemeanour under one set of circumstances, and recognises as a true course of policy under another.

We do not doubt that the most obvious way in which smuggling could be put down is to render it unprofitable, but we cannot also doubt that an equally effective and a more enduring check is to render it unpopular: and that no better means can be found for this result than those which lead the public to understand that the policy of the government in the imposition of taxes is purely fiscal, and that therefore any fraud on the revenue is a robbery of honest tax-payers. It is by these means that the practice of smuggling has been, as all admit, checked. For although the tariff of duty-paying commodities has been much simplified, there is still a number of articles the duty on which is many times more than the prime cost, and which, therefore, on the ordinary hypothesis that smuggling is the inevitable consequent of high customs duties, should be smuggled largely. Public morality is not much furthered by the regulations of government, but it may be, and often is, very seriously injured by an impression that the action of government is unfair, capricious, or interested, or that the proceeds of the public revenue are squandered.

It is possible that smuggling has been to some extent discouraged by the provisions of 16 & 17 Vict. cap. 107, by which armed combinations for smuggling purposes are made felonies. But it is certain that such an Act would be inoperative, if the growth of public morality had not prepared the nation to treat smuggling as a social and not merely as a political crime.

Smut (A.-Sax. smitta). A disease incidental to corn crops, by which the farina of the grain in the whole body of the seed is converted into a black soot-like powder. It is to be regarded as a fungus growth and receives its name from the sooty, dusty mass into which the substance of the seed and seed-vessel is converted under its influence. Mr. Berkeley tells us that means used in preparing seed-corn against bunt may be effectual against smut; but this can scarcely be the case, as the spores of the latter are so much more freely dispersed.

Smyrnium (Gr. *σμύρνα*, *myrrh*). The name of a genus of *Umbelliferæ*, one species of which, *S. Olusatrum*, not uncommon in some parts of Britain, was formerly used as a pot-herb. This plant, commonly called Alisander or Alexanders, is a biennial, usually met with near the sea, as well as in the vicinity of old houses, where it might have been formerly cultivated. Before the introduction of celery, the leafstalks, which are the edible parts, were blanched, and used either as a salad or pot-herb. The flavour somewhat resembles that of celery, but it is stronger and not so agreeable, on which account it has been neglected, and has almost entirely gone out of cultivation.

Snail (A.-Sax. snægel). The name given to the common shell-bearing molluscous animal of this country, applicable to all the various kinds of terrestrial and arboreal species of pulmonated or air-breathing testaceous gastropods. It is properly restricted to those of the genus *Helix*, in which the aperture of the shell is lunate, wider than it is deep, with the margin commonly thickened and reverted. The common snail of this country is the *Helix nemoralis*. In the localities where the Roman colonists dwelt, a larger Italian species, *Helix pomaria*, has become acclimated; it is susceptible of great increase of size by artificial feeding, and was esteemed a dainty by the Romans.

Snail Plant. The popular garden name for the *Medicago scutellata*, the fruit of which resembles snails.

Snake (A.-Sax. snaca). The common term applied to all ophidian reptiles. The British harmless snake is the *Coluber natrix*, Linn.

Snake Root. This term is applied to the root of the *Aristolochia serpentaria*, a native of Virginia: it is a fibrous, aromatic, and bitterish root. The infusion is occasionally used as a tonic and diaphoretic: in typhoid fevers it is a good adjunct to Peruvian bark, and to quinia.

Snake Weed. The great Bistort, *Polygonum bistorta*. The root is *twice bent* on itself, hence the name. This root contains starch, which renders it nutritive; hence, in Siberia, it is roasted and eaten.

Snake Wood. The wood of the *Strychnos colubrina.* Supposed to be an antidote to the poison of certain snakes.

Snapdragon. The well-known garden flower, *Antirrhinum majus.*

Snaped Timber. In Shipbuilding, a timber so cut away, that one face is narrower than that opposite to it.

Snatch Block. On Shipboard, a block with a single sheave, and a notch through one side above the pulley, to enable the rope to be lifted in or out, without the necessity of an end being passed through. It is of use where pressure from the side is required to be applied to a rope already in a state of tension, without diminishing that tension.

Sneezing (A.-Sax. niesan, Ger. niesen). A convulsive action of the respiratory organs, brought on by irritation of the nostrils. Violent fits of sneezing are even said, in some instances, to have proved fatal; recourse must in such cases be had to soothing the nasal membrane by the application of warm milk and water, or decoction of poppies.

Snifting Valve. The valve through which the air and water are expelled from a condensing steam engine when the engine is blown through. In starting a condensing engine, the first operation is to produce a vacuum within the condenser, which is accomplished by opening a valve called the *blow-through valve,* which permits the steam from the boiler to pass through the engine, filling all its vacant spaces, and finally escaping through the snifting valve, which is of the spindle construction, like a safety valve, and which is lifted by the steam. The steam expels all the air and water within the engine; and when this has been done, the blow-through valve is shut, the snifting valve shuts of its own accord, and the steam within the engine speedily condenses from the escape of heat from the surfaces of the engine, and a vacuum is consequently formed, which enables the engine to be readily started.

Snipe (Dutch snip). The common name of the *Scolopax gallinago,* Linn. This bird is a plentiful species in most parts of Great Britain. In wet seasons it resorts to the hills and higher grounds; in ordinary seasons it frequents marshes. Its principal food is worms, in quest of which it penetrates the soft earth with its long and slender bill, which is especially organised for that purpose.

Snow (Ger. schnee, Fr. neige, Lat. nix, nivis, Gr. νίφα). Congealed water, which falls from the atmosphere. Very little is yet known respecting the formation of this meteor. The only observations which may be considered as in any degree complete have reference to the different forms which the flakes assume. This subject was considered by Kepler, Hooke, Cassini, Muschenbroek, and many others; but the most interesting series of observations hitherto obtained are those of Scoresby, and more recently of Glaisher, who have reduced the different forms into classes, and given a number of excellent representations of the flakes in different states. The crystals belong to the rhombohedral system, and when examined with a lens are generally seen to consist of stars of six rays formed of prisms united at angles of 60°, from which other prisms shoot at similar angles, giving the whole an appearance of exquisite beauty and great regularity. The variety of modifications is probably owing to the state of the atmosphere when the snow is formed. If the crystallisation takes place when the air is calm, the crystals will be regularly formed; but they will be irregular and imperfect when the air is much agitated. Sometimes the flakes are granular, and present no traces of crystallisation.

An experiment of Professor Tyndall's has shown in a very beautiful manner that ice is but an agglomeration of snow crystals; the transparency of the former being due to the expulsion of the air entrapped in, and causing the whiteness and opacity of the latter. By exposing a piece of clear ice to the radiation from the sun, a flame, or a bright fire, numberless minute specks are suddenly developed within the ice. After a few seconds' exposure these attain a diameter of about 0·1 of an inch, and when examined through a lens are seen to be little six-rayed stars; the less developed ones resembling tiny flowers with six petals each. These *ice-flowers* are composed of water resulting from the disintegration of the ice by radiant heat, and indicate the way in which the ice originally crystallised; hence, as we should expect, their planes are parallel to the plane in which the ice froze. When the ice-flowers are compared with snow crystals, the two are essentially the same, the rays and serrations in both following the common angle of 60°.

Snow is much less dense than ordinary ice. The bulk of a given weight of ice is only about one-twelfth greater than that of the water from which it is formed, while the bulk of new-fallen snow is ten or twelve times greater than that of the water obtained by melting it. At moderate elevations above the sea, and in the mean latitudes, snow most frequently falls after some days of pretty hard frost, and when the temperature of the air, though still a few degrees above the freezing point, is sensibly mitigated. On this circumstance is founded the remark (which, however, does not always hold good), that it cannot snow in very severe cold.

Red Snow.—It had been remarked by the ancients that snow sometimes assumes a red tint, and Pliny ascribes the cause to age: 'Ipsa nix vetustate rubescit.' Many modern observers have described and examined this curious phenomenon, which appears to be met with in all parts of the world. Saussure observed red snow on the Brevan in 1760, and on St. Bernard in 1778; and he supposed the colouring matter to consist of a vegetable dust. Ramond met with it in the Pyrenees, Captain Ross in Baffin's Bay; Parry, Franklin, and Scoresby collected it in still higher northern

latitudes; and it has been found abundantly in New Shetland in latitude 70° south. Among the Alps it is generally found in low sheltered spots, penetrating to the depth of two or three inches; or rather the strata in which it is found (for it occurs overlaid at considerable depths) are about two or three inches in thickness. The colouring matter of this singular substance has been examined by Wollaston, Agassiz, R. Brown, De Candolle Thenard, Bauer, &c. Dr. Wollaston first remarked that it is composed of minute spherical globules, which have a transparent envelope, and are divided into seven or eight small cells filled with a species of red oil insoluble in water. Mr. R. Brown and De Candolle supposed the globules to be a kind of alga. Mr. Bauer (*Phil. Trans.* 1820) found the globules to be exactly identical in snow collected in Baffin's Bay and New Shetland; and he supposed them to be a small fungus of the genus *Uredo*, forming a peculiar species, to which he gave the name of *Uredo nivalis*. Red Snow is really an alga, now known under the name of *Protococcus nivalis.*

Snow Line, or Limit of Perpetual Snow.—Since the temperature of the atmosphere continually diminishes in ascending from the surface into the higher altitudes, there must be in every latitude a certain limit of elevation at which the air attains the temperature of freezing water. This limit is called the snow line, or line of perpetual congelation; and the mountains which rise above it are covered with perpetual snow. Within the tropics the temperature varies little throughout the year, and hence the snow line is distinctly marked; but in countries remote from the equator the limit of congelation rises in summer and descends in winter through a band or zone of considerable breadth. The line of *perpetual* congelation is of course the summer limit. The altitude of the snow line, however, is dependent not upon latitude alone, but also on the configuration and aspects of the mountain chains, the extent and temperature of the surrounding plains, the quantity of snow that falls annually, and the multitude of causes which influence the climate of a country. [CLIMATE.] On the Himalaya chain, for example, the limit of perpetual congelation on the northern side is at an elevation exceeding by upwards of 4,400 feet that on the southern side, though the latter is directly exposed to the sun; a circumstance which Humboldt ascribes to the radiation from the great plain of Thibet, the general serenity of the climate, and the rarity of snow in an exceedingly cold and dry atmosphere. No dependence, therefore, can be placed on any general rule for estimating the height of the snow line, and it affords an exceedingly fallacious indication of the altitude of mountains. The following table is given by Humboldt in his *Fragmens Asiatiques*, p. 549. The elevations stated are the heights of the line of perpetual congelation above the level of the sea, and the measures are reduced to English feet.

Mountain Chains	Latitude	Elevation of Snow Line
		Feet
Cordilleras of Quito	0°— 1½° S.	15,730
Cordilleras of Bolivia	16 —17¾	17,060
Cordilleras of Mexico	19 N.	15,030
Himalaya, Northern side	31	16,940
Himalaya, Southern side	31	12,470
Pyrenees	43	8,950
Caucasus	43	10,870
Swiss Alps	46	8,760
Carpathians	49	8,500
Altai range	50	6,395
Norway, Interior	70	3,518
Norway, Coast	71½	2,302

(See, in addition to the works already cited, Scoresby, *Account of the Arctic Regions*, 1820; Humboldt, 'Mémoire sur la Limite de Neige perpetuelle dans les Montagnes de l'Himalaya, et les Régions Equatoréales,' in the *Annales de Chimie*, tome xiv.)

Snowball-tree. The sterile-flowered variety of *Viburnum Opulus*, commonly known as the Guelder or Gueldres Rose.

Snowdrop. The name of one of our earliest flowers, belonging to the genus *Galanthus*, which poets designate the 'first pale blossom of the unripened year.'

Snowdrop-tree. *Chionanthus virginica*, a handsome hardy tree, bearing a profusion of white flowers.

Snowflake. The name given to the *Leucojum*; a spring or early summer flower, much resembling a snowdrop.

Snuff (Dutch snuif). Tobacco prepared for use by being dried and ground into powder. It is made from the stalks only of the tobacco plants, from the leaves only, or from a mixture of both stalks and leaves. In this way, and by mixing these qualities in varying proportions, the many different kinds of snuff are produced. High-dried snuffs owe their peculiarities to being dried so as to produce a kind of scorched flavour. Scotch snuff is manufactured wholly, or almost wholly, of tobacco stalks.

Sny. An expression for the position of a curved plank worked edgeways into the bow of a ship.

Soap (Ger. seife, Gr. σάπων, Lat. sapo). This useful compound is obtained by the action of alkaline upon oily substances. There are, accordingly, a great variety of soaps; but those commonly employed may be considered under the heads of: 1. Fine white soaps, scented soap, &c.; 2. Coarse household soaps; 3. Soft soaps. The materials used in the manufacture of white soaps are generally olive, palm and other oils, and carbonate of soda: the latter is rendered caustic by the operation of quicklime, and the solution thus obtained is called *soap ley*. The oil and a weak ley are first boiled together, and portions of stronger ley are gradually added till the soap, produced by the mutual action of the oil and alkali, begins to become tenacious and to separate from the water; some common salt is added to promote the granulation and separation of the soap; the fire is then drawn, and the con-

tents of the boiler allowed to remain for some hours at rest, so that the soap may more completely collect. When it is perfect, it is put into wooden frames or moulds; and when stiff enough to be handled, it is cut into oblong slices and dried in an airy room. Perfumes are occasionally added, or various colouring matters stirred in whilst the soap is semifluid, to give it a mottled appearance. The Spanish soap is *marbled* by stirring into it a solution of sulphate of iron, which is decomposed by the soap, and black oxide of iron separated in streaks and patches through the mass. The action of the air converts the exterior into red oxide, whilst the interior long retains its black colour; hence a slice of this soap presents a black mottled centre, surrounded by a reddened external layer.

Common household soaps are made chiefly of soda and tallow and other common fats. Yellow soap has a portion of resin added to it. Soft soaps are generally made with potash instead of soda, and fish oil. The common soft soap used in London is a compound of this kind; it has a tenacious consistence, and appears granulated. Soap is soluble in pure water and in alcohol; the latter solution *jellies* when concentrated, and is medicinally known under the name of *opodeldoc*. When carefully evaporated, the soap remains in a gelatinous state, which forms, when dry, the article sold under the name of *transparent soap*.

The earths and common metallic oxides form *insoluble soaps*; and accordingly these are precipitated when earthy and metallic salts are added to solution of soap. It is the sulphate of lime and carbonate of lime in common spring water which thus render it unfit for washing, and give it what is termed *hardness*; and, upon this principle, a spirituous solution of soap is a simple and valuable test of the fitness of any river or spring water for the purposes of the laundry. If it merely renders the water slightly opalescent, as is the case with rain and other soft waters, it may be used for washing; but if it become milky, it is usually too hard to be conveniently employed; and when we wash with hard water, the separation of the insoluble calcareous soap is extremely disagreeable: it adheres to the skin, and soils instead of cleansing it.

The chemical nature of soap has been laboriously examined by Chevreul, who has shown that the alkali in the process of saponification converts the oil into peculiar *acids*, the elain of the oil forming *oleic acid*, the stearine *stearic acid*, and the margarine *margaric acid*; so that soluble soaps are oleates, stearates, and margarates of soda and potash. He has enumerated several other fatty acids similarly produced.

All new soaps contain a considerable portion of adhering water, a great part of which they lose when kept in a dry place; hence the economy and excellence of *old* soap; and hence the dealers in soap generally keep it in a damp cellar, that it may not lose weight by evaporation, or sometimes immerse it in brine, which does not dissolve it, but keeps it in its utmost state of humidity.

Soap may be considered as a necessary of life; in all civilised countries its consumption is immense. According to Pliny, the invention of soap must be ascribed to the Gauls, by whom, he says, it was composed of tallow and ashes, though the German soap was considered the best. The great seats of the soap manufacture in Great Britain in 1852 were London, Liverpool, Bristol, Runcorn, Glasgow, Greenwich, Gateshead, and Warrington. Thus of 184,725,265 lbs. of hard soap made in 1851, London supplied 44,034,102 lbs.; Liverpool, 39,384,595 lbs.; Bristol, 12,898,630 lbs.; Runcorn, 11,787,360 lbs.; Glasgow, 10,642,219 lbs.; Greenwich, 8,712,130 lbs.; Gateshead, 7,131,590 lbs.; Warrington, 5,147,090 lbs. These figures are supplied from the returns of the last year on which soap was liable to an excise duty, for the tax on soap was repealed in 1853. Up to 1833, the tax had been 3*d*. per lb. on hard soap; it was then lowered to 1½*d*. In 1852, the net revenue derived from soap was 1,126,046*l*. At present it is not possible to determine with any certainty what is the annual manufacture of soap, but it is certain that the amount has increased enormously. The amount exported from Great Britain and Ireland is not large, and appears to diminish, ranging between 15,000,000 and 25,000,000 lbs. [FATS; OILS.]

Soap Bubbles. The addition of a small amount of the soluble salts of the fatty acids to water modifies the cohesion of the particles of that liquid in a remarkable degree, and permits of bubbles being formed of considerable size and permanence. The soda soaps possess this property in the highest degree, and the method of blowing soap bubbles with a tobacco pipe is too familiar an experiment to require description. The extraordinary distensibility of the bubble is dependent on the equality of the strain in all parts of the film; hence it follows that all circumstances which derange this equilibrium cause the destruction of the bubble, as is seen in the case of contact with greasy or porous objects. The evaporation of the liquid necessarily produces the same result, so that the ordinary bubble is as evanescent as beautiful. When the liquid film becomes sufficiently thin, it begins to exhibit the colours produced by the interference of light. [INTERFERENCE.] These tints are frequently of great splendour, and when closely examined are seen to consist of sinuous streaks which mark the lines of equal thickness of film. The bubble solution of M. Plateau, by increasing the permanence of the films, allows these effects to be more readily observed, and renders soap bubbles available for many physical experiments. The recipe for this solution is as follows: Dissolve one part of *pure* oleate of soda in 50 parts of distilled water, and mix this solution with two-thirds of its volume of glycerine. Bubbles blown with this solution can be preserved upon rings

of iron wire for many hours, or attached to small discs of paper held by a thread. The colour-effects in these bubbles can best be examined in the following manner. The stage of a compound microscope is covered with black paper or velvet and a loop of wire is placed on it to form a support for a small bubble. The latter is illuminated on its upper surface by a good condenser, and the light thus reflected is received on an object glass of low power. By this means optical effects of great splendour and variety become evident, depending on the degree of attenuation of the film. The thickness of the latter is estimated to be usually somewhat thicker than that of ordinary gold leaf.

Soap-test. On washing in hard water no lather can be obtained until the lime and other hardening salts have been decomposed by, and have decomposed, the soap. The product of the decomposition is the well-known *curd* which floats on the surface of the water. This action being definite, the *hardness* of waters may be determined by adding to equal quantities of them a solution of soap of known strength until a permanent lather is produced on shaking. Such a soap solution is called a *soap-test*.

Soapstone or **Steatite.** A hydrated silicate of magnesia, with a smooth greasy feel like that of soap, and so soft as to yield to the nail. It is a massive variety of Talc, which, when pure and compact, is much used as a refractory material for lining furnaces, being infusible in any ordinary furnace heat. It is easily turned in the lathe or cut with knives and saws, and is made into culinary vessels.

When very strongly heated, Soapstone loses the small portion of combined water which it contains, and becomes harder and susceptible of polish. In this state it is made into jets for gas-burners, which have the advantage of not being liable to rust or corrosion. When reduced to powder, it is used like Plumbago as a lubricator and to diminish friction, as well as to give a surface to some kinds of paper-hangings.

The soapstone of Mylos is an important article of commerce in Turkey and Russia, where it is used instead of soap.

It is found in Cornwall near the Lizard Point in Serpentine; at Portsoy, Banffshire, and in Canada. [STEATITE; TALC; VENETIAN CHALK.]

Soapwort. The common name for *Saponaria*, and especially *S. officinalis*.

Soave, Soavemente (Ital. *sweet, sweetly*). In Music, a term denoting to the player that the music to which it is prefixed is to be executed with sweetness.

Sobriquet. In French, a burlesque appellation or *nickname*. The word has been variously derived from the Lat. subridiculum, subrusticum, and the Gr. ὑβριστικόν, &c. There is a curious dissertation in vol. xiv. of the *Hist. de l'Acad. des Inscr.* on the authority of these appellations in history.

Socage (Mod. Lat. socagium, from A.-Sax. soc, *privilege*). This term denotes, according to Blackstone, in its original and most extensive signification, a tenure by any certain and determinate service. The sokemen at and immediately before the Norman conquest appear to have been in the lowest ranks of free cultivators of the land, being classed along with the villein in a law of Edward the Confessor. But by the time when the works of Bracton and the author of *Fleta* were compiled, socage had come to signify any tenure not military or quasi-military; i.e. either where military services were due (tenure in chivalry or by knight service), or other services of an honorary kind, such as by the French feudal law were due on what were called imperfect fiefs (tenure by grand serjeanty). Socage, therefore, comprehended various descriptions of tenure, and has been generally divided into *free* and *villein* socage. In free socage, the services were certain, and, in the feudal sense, not base or dishonourable, as the payment of an annual rent; and none of the feudal incidents of wardship, &c., were demandable in respect of lands so held, although certain aids and reliefs were peculiar to socage as well as to knight service. By the stat. 12 Ch. II. c. 24, when military tenures were abolished, all sorts of tenures held of the king and others (except frank-almoign, copyhold, and the honorary part of grand-serjeanty) were turned into tenure by free or common socage. Villein socage was a species of tenure in lands held of the king by certain villein services, but certain and determinate; from which mixed species of tenure arose that in ancient demesne. Lands so held are deemed to be in certain respects copyhold; and these were within the exceptions of the statute 12 Ch. II., and still subsist. [TENURE.]

Social Science. The examination of the various facts and principles under which society is constituted, and by which it is regulated, has in the course of time, and in consequence of the great collection of observations upon the subject, been taken from several different points of view, some of which are precise and determinate, others vague and somewhat shifting. Thus, the purely economical aspect of social life is of the former character. The lines of political economy are positive and unyielding, and the inferences which the economist arrives at are exact, scientific, demonstrative, invariable. On the other hand, the philosophy of politics not only tolerates exceptions, but contemplates the contest or opposition of interests and sentiments as a normal and almost necessary state. The constitution of the several European states differs largely, and, on the whole, all these differ from the political system which has been accepted in the New World, because undoubtedly government is a means to an end, the end being possibly arrived at by various means. This end may indeed be achieved best by particular forms of government, but it seems generally admitted that, unless the form is radically vicious, it is better that the true purposes of society should be worked out gradually by the fair and free

contest of forces, than to impose a special form of government on a people for which it is not willing, or even, if willing, not prepared.

Social science occupies a position intermediate to Political Economy and Political Philosophy. It does not discuss or expound the exact theories of the former, nor does it examine the problems of the latter; but it deals with the effect of existing social forces, and their result on the general well being of the community. Some of these forces are universal and natural, others are municipal or artificial. Thus, the theory of money and its substitutes is a purely economical consideration, the discussion of which has no place in social science. So the various views current on the most effectual and safe representation of the people form part of political philosophy, and as such lie out of the domain of social science. On the other hand, the extension or shortening of human life under sanitary or insalubrious conditions, is a question of eminently social interest, and is, it appears, under ordinary atmospheric or other conditions, susceptible of scientific demonstration. So in another manner, the enquiry into the consequence of certain laws and systems affecting the distribution or accumulation of land is a social question indeed, but one which arises directly from a municipal or factitious ordinance. Furthermore, social science is much more indebted to statistics than political economy is. For example, the ease or difficulty with which the greater part of the community can be supplied with certain necessaries or conveniences of life, such, for instance, as meat, is almost exactly determined by such agricultural statistics as have been lately obtained with extreme difficulty and under the pressure of an exceptional agricultural calamity.

Associations for the purpose of expounding and discussing the principles and details of social science have been long in existence in France, under the name of Sociétés de Bienfaisance. A similar association was established in England, originally in order to give scope for the discussion of many questions which pressed upon the economic science section of the British Association. The first meeting of the Social Science Association was held at Birmingham, under the presidency of Lord Brougham, who has also been, except in the two years 1858, 1859, its president ever since. The business of the association, after hearing an address from its president, is to divide itself into several sections, which have hitherto been four: 1. Jurisprudence and the Amendment of the Law; 2. Education; 3. Health; 4. Economy and Trade, and to hear and comment on papers composed on the various subjects comprised under these general heads. The value of these associations cannot be disputed. They not only form a means by which observations are recorded and truths elicited both by induction and by debate, but they familiarise the public to a greater or less degree with a variety of important questions and a number of unquestionable inferences.

The progress of social science has resulted in the adoption of many important social reforms. Among these may be enumerated the general developement of a sound theory of sanitary science, and the extensive use of precautions against ordinary, epidemic, and endemic disease; the reconstitution of hospital charities; the regulation of prisons and workhouses on sounder and truer principles than those which had hitherto been accepted; the establishment of reformatories and penitentiaries for youthful offenders and reclaimed prostitutes; the extension of education, particularly of middle class and industrial education; and many other important results. Great, however, as have been the effects of these investigations, it cannot be doubted that much remains to be done, and that many problems await their solution at the hands of such persons as have already effected much, and at those of their successors in these branches of practical philanthropy. But social science, the reforms which it institutes, and the charities which it regulates and instructs, occupy of necessity a far inferior position to the developement of the leading subject which is discussed by its advocates, i.e. the amendment of the law. The widest benevolence is but a poor substitute for righteous legislation; or, to state the proposition in another form, one just law is worth a million acts of charity, since its operation is wider and its effects are more lasting.

Social War. In Roman History, this name is given to the struggle (B.C. 91) in which the Italian tribes, who were specially termed the allies of the Roman state, fought for admission into Roman citizenship. This admission would give to them, as to other plebeian citizens, the right to share in the distribution of public lands, and would thus enable them to recover the property of which they had been dispossessed by conquest or encroachment. The war was soon brought to an end by timely concessions of the franchise.

Socialism. (Lat. socialis, from socius; Sansc. sakhi, *a friend*). In Political Philosophy. No very accurate distinction in point of meaning between the words *socialism* and *communism* has been shown. There is, however, a slight difference in common usage, which the following remarks may elucidate.

1. It is held by some theorists that the notion of *property* has no foundation either in right or expediency; that as, in point of fact, the possession of property was originally merely the usurpation of superior strength, so, in a really equitable state of society, this usurpation would altogether disappear; that, in Proudhon's epigrammatic phrase, *property is robbery*. This doctrine of the absolute community of goods is ordinarily designated as *communism*.

2. But between this extreme and that which regards the right of individual property and the use of it as not to be interfered with at all, except in certain extreme cases recog-

nised by ordinary legislation, there is a wide interval. There are many intermediate theories, according to which the use of property ought to be restricted or interfered with, or property itself, when beyond a certain amount, divided, for the common good, or rather that of the majority. These theories commonly pass under the general name of Socialism, and in this sense not only the theories of philosophers, but many existing or proposed laws and usages, may be regarded as Socialist in their tendencies. Such are: agrarian laws, limiting the quantity of land to be held by an individual; laws fixing the maximum of rent, or the minimum of wages; laws interfering in other ways between the capitalist and the labourer (for shortening the duration of labour, and the like); the usages of trades' unions; nay, poor laws, and income taxes limited to the higher classes; all these, some of them innocently, others intentionally, bear in the same direction.

Socialism in this sense had a large part in the institution, and still larger in the theories, of classical antiquity; see the *Republics* of Plato and Aristotle, and the recorded usages of Lacedæmon and of ancient Rome. But in the middle ages it may be said to have entirely disappeared, except in so far as it was kept alive by religious tradition, from the (historical or imaginary) community of goods said to have prevailed among the early Christians. Hence, with the revival of political speculation, socialism may be said to have made its way to the light through two different avenues: 1. That of religious theory (Anabaptists, Herrnhuters, Moravians, &c. &c.), and that of political theory derived from the ancients (More's *Utopia*, Harington's *Oceana*, the ideal reforms of Fénelon, Rousseau, Morelly, and so forth). But the leaders of the first French revolution, amidst all the wild excesses of political fanaticism in which they indulged, were generally either entirely opposed to communistic theories or ignorant of them. Robespierre, for example, who could foresee the probable extension of the republicanism which he advocated into wider changes, wished to declare the 'sacredness of property,' among the fundamental positions of the *rights of man*; but was overruled by others, not because they disapproved of his views, but because they did not see the necessity for proclaiming them.

The first disciples of progress who openly denounced the right of property as the fundamental error of society were Babeuf and his followers, who attempted an insurrection against the Directory in 1797. In his paper, the *Tribun du Peuple*, Babeuf advocated the division of property, without endeavouring to establish any very definite substitute.

Robert Owen of Lanark (born 1771, died 1858), stands in point of date next to Babeuf among the leading advocates of Socialism. (*New View of Society*, 1812; *New Model World*.) Owen's views cannot be said to have assumed any very definite or logical shape, but they undoubtedly assumed community of property as the real basis of social regeneration.

Saint Simon (Claude Henri, Count, born 1760, died 1825), though an older man than Owen, came forward much later as a leader having influence on mankind. His theory partook of the religious as well as the political aspect of Socialism. Property was to be in common. But the enjoyment of it by individuals was to be regulated by a superior authority; a theocratic government, established among mankind by force of superior wisdom and intelligence, was to have the duty of assigning to everyone his allotted task in society and his allotted retribution. His views are chiefly embodied in his *Nouveau Christianisme*, published after his death by Rodriguez. It is strange that theories so absolutely unpractical, and with so strong a tendency to the ludicrous as well as the absurd, should have found favour as they did in France, at the period of the Revolution of 1830. For a time, the 'Saint Simonian' sect played a very conspicuous, if not a really important, part in society; and though after many scandals it was ultimately dissolved by government (1832), many of its leading sectaries have since taken substantial part in public affairs.

Charles Fourier, of Besançon (born 1772, died 1837), was a leader of more original stamp and more powerful mind. Going somewhat deeper into human nature, he developed the theory that all the tendencies of man are naturally good, and that the real function of government is simply to favour and direct their developement. For this purpose not only is community of property necessary, but a thorough disciplinary training of the human race in all the functions of life; to be carried out in distinct communities of a certain number of families, which he designated by the name of 'Phalanstères.' The notions of Fourier, like those of Saint Simon, are chiefly to be collected from posthumous works, especially his *New Industrial World*, 1839.

Etienne Cabet (born 1788) is the last Socialist authority of whom it is necessary to make detailed mention. According to his ideas, an imaginary *state* is to regulate the life of every member of society. This he developed in an imaginary *Voyage en Icarie* (1842), adapted chiefly, it is said, from fragments of old romances. He had success enough (like Owen) to be able to establish a real 'Icaria' by subscription, in the United States (Texas), in 1848. The scheme failed, and its founder was prosecuted in Paris as a swindler (1851) but acquitted.

Society (Lat. societas). The term usually applied to an association formed for the promotion of some object, either literary, religious, benevolent, political, or convivial. Associations formed for commercial purposes are usually styled COMPANIES. The chief literary societies of Europe have been noticed under ACADEMY. The purposes for which *benevolent* and *religious*

societies are formed will be best inferred from the epithets with which they are connected; thus, *temperance* societies are established with a view to promote sobriety, *mendicity* societies for the relief of the indigent, &c.

It is proposed in the present article to give a brief account of the principal societies which now exist, particularly in England, both of the learned and beneficent classes; but the number of those of which special notice can be given is necessarily very limited.

1. 'The Learned Societies of the United Kingdom' are classified by the Rev. Mr. Hume in his account of them (1853) as, 'Metropolitan and Provincial,' in each of the three kingdoms, besides one which he styles 'National, not Metropolitan,' namely, the 'British Association for the Advancement of Science,' instituted in 1831, which holds its meetings annually at places in the United Kingdom designated beforehand.

The Metropolitan Learned Societies are as follow:—

Scientific:
- Royal
- Royal Astronomical
- Geological
- Linnean
- Chemical
- Zoological
- Royal Asiatic
- Royal Geographical
- Ethnological
- Anthropological
- British Meteorological
- Acclimatisation
- Microscopical
- Royal Botanic
- Royal Horticultural
- Entomological
- Photographic
- Institute of Actuaries
- Association for the Promotion of Social Science
- Statistical
- Institution of Civil Engineers

Archæological:
- Antiquaries
- Archæological Institute
- British Archæological Association
- Surrey Archæological
- Syro-Egyptian

Literary and Publishing Societies:
- Camden
- Ecclesiological
- Hakluyt
- Palæontographical
- Ray
- Royal Society of Literature

Medical:
- Epidemiological
- Medical
- Royal Medical and Chirurgical
- Obstetrical
- Pathological

Art and Architecture:
- Architectural Association
- Arundel
- Graphic
- Royal Institute of British Architects
- Musical
- Society of Arts and Manufactures

Various:
- Law Amendment

Besides these societies so called, there are other bodies, such as the Royal Institution of Great Britain, Royal College of Surgeons, Royal College of Physicians, United Service Institution, and London Institution, where, in addition to the holding of stated meetings, other objects are sought to be obtained. Of all these societies, the Royal Society is the most important. It originated in an assembly of persons interested in natural history and experimental philosophy, who began to hold weekly meetings about the year 1645; at first in London, afterwards in two divisions, partly at Oxford, partly in London. In 1663, they were incorporated by King Charles II., as a president, council (twenty-one in number), and fellows, 'for promoting natural knowledge.' Their experiments and discussions are published from time to time under the title of *Philosophical Transactions*. It has 830 British and foreign members: its apartments, granted by the crown, are in Burlington House. Several works on its history have been published; of which the latest and most complete is that by Mr. Weld, its assistant secretary and librarian (1848). [ACADEMY.]

The Society of Antiquaries was founded about 1572 by Archbishop Parker; it assembled, as a private body, for several years in the house of Sir Robert Cotton. It is said to have acquired so much influence as to have excited (it is not easy to see why) the jealousy of James I., and to have been dissolved by him. It was revived in the eighteenth century, and incorporated in 1750 by George II. Its principal object has always been the prosecution of enquiries relating to British history and antiquities, though others are not excluded. Its transactions are published under the title *Archæologia*. There are about 600 members. Place of meeting, Somerset House, in the rooms vacated by the Royal Society on its removal to Burlington House. [ACADEMY.]

The London Society for the Encouragement of Arts, Manufactures, and Commerce, more briefly styled *Society of Arts*, was instituted in 1754; the principal agent in its establishment having been Mr. William Shipley, who was originally a mechanic. The chief objects of its encouragement have been defined 'ingenuity in the arts, useful discoveries and improvements in manufactures, agriculture, mechanics, and chemistry, or the laying open of any such to the public; and, in general, all such useful inventions, discoveries, and improvements, as may tend to the advantage of trade and commerce.' These are promoted, in the first place, by premiums of medals, granted out of the very considerable funds of the society, to inventors, &c., but with the express exclusion of patentees, or those who propose to become such. The society has also become the originator of many similar bodies constituted on the same principles. But its chief, or at least most celebrated, result has been the establishment of the *Royal Academy of Arts*, now an independent body. It has 800 ordinary members.

In almost all these societies, except the Royal Society, the payment of the entrance fee and annual subscription constitutes the most important qualification for membership. In the Royal Society the case is very different; of all the candidates a certain fixed number only is annually chosen and recommended for election by the council.

Most of the important societies have very valuable libraries of reference, and nearly all publish accounts of their proceedings and memoirs, some of which are of the highest importance. The Archæological Institute, British Archæological Institute, and Association for the Promotion of Social Science, like the British Association, hold annual congresses in different parts of the kingdom.

The number of provincial societies, field

clubs, &c., is rapidly increasing, and their present number is very large.

Among the Scottish, Irish, and British provincial societies of eminence may be noticed the *Royal Society of Dublin*, founded in 1734 'for the encouragement of husbandry and the arts;' the *Royal Society of Edinburgh*, founded in 1739; and the *Literary and Philosophical Society of Manchester*, the oldest provincial body, founded in 1781.

In France, the number of scientific and literary societies is very great, and their affairs are to a certain extent subject to the inspection of government. In 1845, it was declared by an *ordonnance royale* that a volume should be published under the Department of Public Instruction, to be styled the *Annuaire des Sociétés Scientifiques et Littéraires du Royaume.* The volume for 1846, which appeared accordingly, contained a short history, and a copy of the rules of nearly 400 such bodies, metropolitan and provincial; the Institut [ACADEMY; INSTITUTE] being regarded as the chief of all. No more volumes of the *Annuaire* were published; but the *Revue des Sociétés Savantes* continues to afford similar information.

2. Among English societies for the promotion of charitable or humane, as distinguished from religious and educational, purposes, may be mentioned: the *Society for the Establishment of a Literary Fund*, instituted in 1790, of which the purpose is to administer relief, by gratuities and pensions, to necessitous literary persons; and the *Royal Humane Society*, 'for the recovery of persons drowned or otherwise suffocated,' instituted in 1774.

3. Lastly, to turn to the societies established among us for educational, as well as for missionary and other religious purposes; it has been said with truth that, with respect to these, England has a right to claim a place in the foremost ranks of civilisation, whether we regard the number or the principles of its religious and benevolent institutions. The notice of a very few leading ones must suffice.

Society for the Diffusion of Useful Knowledge.—This society was originally founded under the management of a committee of gentlemen, assembled under the presidency of Lord (then Mr.) Brougham, in 1822, established and incorporated in 1832. It was at first maintained by subscription, but since its earlier years entirely by the sale of its publications. The revenue derived by it from its works is usually a rent paid by the publisher for the use of the copyright. In this way it has produced (besides many works of inferior art) its Libraries of Useful and Entertaining Knowledge; *Almanac and Companion*; maps; *Penny Magazine*, and *Cyclopædia*, &c. &c.

Society for the Promotion of Christian Knowledge, founded in 1698, has continued from that time to be the principal agent of the church of England for the diffusion of the Scriptures, and her own formularies both at home and in foreign parts.

British and Foreign Bible Society, established in 1804, 'with the sole object of encouraging the circulation of the Holy Scriptures *without note or comment.*' In the recent reports of this body, it claims to have been the means of circulating nearly 50,000,000 copies of the Bible, of which nearly half have been circulated in this country, the larger proportion of the remainder in Europe and Christian America, the rest among Mohammedans and heathens in other parts of the world.

Society, National, 'for promoting the education of the poor in the principles of the established church throughout England and Wales,' founded in 1811, incorporated in 1817. This society was established in order to carry out in a church of England sense that great movement in favour of popular education, which commenced at the end of the last century. Its assistance is furnished towards church schools, when established by private efforts in any parish, by grants of money, books, legal advice, &c. It has also training colleges for masters and mistresses of schools (St. Mark's, Battersea, Whitelands). It has united to itself 12,200 schools, with 1,157,000 scholars.

Society for the Propagation of the Gospel in Foreign Parts was incorporated, in 1701, 'for the receiving, managing, and disposing of funds, contributed for the religious instruction of the Queen's subjects beyond the seas, for the maintenance of clergymen in the colonies, and for the propagation of the Gospel in those parts. The general income of this great society was about 125,000*l.* in 1864, devoted to the maintenance of missionaries and schoolmasters of the church of England in the colonies; and as to certain portions of it, called 'appropriated funds,' to certain special purposes for which these funds were created. The establishment of the church of England in the colonies, now numbering more than forty bishoprics, has been in a great measure created, and is still to a certain extent maintained by its expenditure; and, of late years, certain 'missionary dioceses' (Niger, Orange River, Melanesia, Honolulu, &c.), have been founded, through its agency, in foreign parts beyond the dominions of the crown.

The *Church Missionary Society*, 'for Africa and the East,' was founded at the end of the last century. Its object is to send out, and support, missionaries of the established church, to preach to the heathen in the foreign possessions of the British empire; the missionaries being placed in subordination to colonial bishops, where these are established. The income was estimated, in 1864–5, at 144,000*l.* The chief scenes of its labours have hitherto been the west coast of Africa, the Pacific, North West America, and more especially British India.

London Missionary Society, for missionary exertion in heathen countries; of which the particular characteristic is, that it is not denominational, and comprehends Christians of various persuasions; founded in 1795; its income at present (both ordinary and extra-

ordinary) exceeds 140,000*l.* per annum. Its principal fields of exertion have been the West Indies and South Africa, and the Pacific, in which the Society and Navigators' Islands (Samoa) have been especially superintended by it.

Among dissenting societies of the same class, two perhaps deserve especial notice. *The Wesleyan Methodist Missionary Society.* Its income in 1864 was about 140,000*l.* The principal seats of missionary enterprise in which this great body has established itself, besides foreign European countries, are British North America, the West Indies, and in the Pacific, more especially the Friendly and Feejee Islands, where a considerable native population is under the teaching of its missionaries. The *Baptist Missionary Society*, with similar purposes, has its most remarkable fields of activity in the West Indies, particularly Jamaica.

In the United States the example has been followed by the establishment of various energetic societies for missionary purposes, particularly that of Boston, New England, to which the conversion of the natives of the Sandwich Islands to Christianity, at an early period of this century, was due.

The vast efforts of the church of Rome towards the extension of the Christian religion among the heathen have been for the most part effected under a very different system of organisation, viz. that of papal supervision. [PROPAGANDA.] Of late years, however, that church has called in aid to some extent the principle of voluntary association. *The Society, or Association, for the Propagation of the Faith*, was founded at Lyons in 1822. It has two councils or governing bodies, one at Paris, the other at Lyons. Its transactions are periodically published under the title of *Annals*. Associates of this body are admitted on payment only of a contribution of a sou per week. These contributions (together with such additions as individual liberality makes) are collected by an organisation of *decuries* and *centuries* and *diocesan councils*. The great seat of activity of its missionaries of late years has been in the South Seas, particularly those groups of islands called, in modern geography, Melanesia.

Societies formed for *convivial* or *political* purposes are most usually denominated *clubs* —a term which may be truly said to be exclusively English, and which embraces so many complex ideas that it is all but impossible to reduce it within the limits of a precise definition. The origin of clubs may be said to date from the end of the seventeenth century. It would be superfluous to call to the reader's remembrance the beau ideal of a club which Addison has drawn in the *Spectator*—the Kit-Kat club, which numbered among its members all the most distinguished persons of the day; the Scriblerus club, of which Swift, Harley, Pope, Gay, and Arbuthnot were members; or that still nearer our own times originally held at the Essex Head, which was ennobled by the genius of Johnson, Burke, Reynolds, Goldsmith, Wyndham, and Fox. They were originally instituted solely for convivial purposes; but in the course of time the term *club* was successively adopted by various political associations, both in this country and on the Continent. Since the commencement of the present century, the chief clubs have been either of an avowed political character, as the Carlton, Boodle, and the Reform Clubs; or devoted exclusively to certain classes, as the United Service, the Oxford and Cambridge; or open to all gentlemen on election, without regard to political party or profession, as the Athenæum, Wyndham, &c. There are about forty clubs in the metropolis. They consist each of a limited number of members, varying from 1,000 to 1,500, who are admitted by ballot, and pay from ten to thirty guineas on their admission, and an annual subscription varying from five to ten guineas. The club-houses are, generally speaking, splendid edifices, which add much to the magnificence of the streets and squares in which they are situated.

The latest appropriation of the term *club* has been made by several associations—such as the Roxburgh club of London, the Bannatyne of Edinburgh, and the Maitland of Glasgow—which were formed for the purpose of printing original MSS., which would not otherwise have seen the light, or of rescuing rare productions from oblivion by reprinting them from scarce and valuable editions.

For the political clubs at Athens, see Grote's *History of Greece*, part ii. ch. lxii. The Roman societies answered to our commercial or professionial partnerships. (Smith's *Dictionary of Greek and Roman Antiquities*, art. 'Societas.') [HETÆRIA.]

Socinians. The followers of Socinus, the uncle and the nephew, both of the same name, and celebrated for similar opinions concerning the nature of Christ. The nephew, Faustus Socinus, was the principal founder of the sect. He was an Italian (born at Sienna in 1539), who desired to be admitted into a society of Unitarians already existing in Poland. Their opinions do not appear to have precisely corresponded with his, and admission was refused him; nor did he effect during his lifetime the institution of any distinct congregation; but the views which he disseminated in his writings were gradually adopted by many ministers and religious communities, especially in Poland, where Crellius, Wolgozenius, and others, published a Socinian system of theology, comprised in the *Bibliotheca Fratrum Polonorum.*

Since the death of Socinus, the theologians who have asserted the mere humanity of Christ have been generally denominated Socinians. The doctrines, however, to which that appellation can with strictness be applied are not precisely equivalent to those of the modern Unitarians. The Socinian denies the existence of Christ previous to His birth of the Virgin Mary; he allows, however, that that birth was miraculous, and considers the Saviour as an

object of peculiar reverence and an inferior degree of worship. By the term Mediator, as applied to Christ, he understands that in establishing the new covenant He was the medium between God and man; and of His sacrifice he says that as the Jewish sacrifices were not made for the payment of sins, but for the remission of them, so also the death of Christ was designed for the remission of sins through God's favour, and not for the satisfaction of them as an equivalent. (Mosheim, art. 'Unitarians.')

Sociology (Lat. socius, Gr. λόγος). A word somewhat barbarously coined by the school of M. Comte [Positivism] to express the science which has to do with man in his social capacity; including politics, political economy, and similar subjects.

Sock (Lat. soccus, Ger. socke, allied to *sack*). The name given to the peculiar kind of shoe worn by the ancient Roman comedians; hence used metaphorically for comedy itself. [Buskin.]

Socle (Ital. zoccoli, *a shoe*). In Architecture, a square member, whose breadth is greater than its height; used instead of a pedestal for the reception of a column. It differs from a pedestal in being without base or cornice.

Socratic Philosophy. This term, in its most extensive sense, is used to comprehend the whole developement of Greek philosophy from Socrates to the Neo-Platonists. The title is so far just, as all the schools of this period, with the single exception of the Epicurean, called themselves by the name of Socrates, and arrogated to themselves the merit of exclusively propagating his doctrines. But more strictly it signifies the direction and method which Socrates gave to philosophical enquiry. The earliest philosophers of Greece directed themselves to the study of external nature, grounded always on some deductive theory [Ptolemaic System], which, as the outward condition of man's existence, attracts and constrains his attention, and so becomes the root and source of his intellectual life also. Hence, they were led to form a single and exclusive science—that of universal nature. But on a wider range of observation, the belief in the affinity of man to the powers of the surrounding world was gradually weakened. Philosophy, then, had now arrived at the point where either the distinction of the ethical and the physical must be set forth in clear evidence; or else, by adhering to the previous direction of thought, the light which had been, however unconsciously, kindled must be obscured and extinguished. To admit the claims of both as two conflicting sciences, with equal pretensions to universality, was inconsistent with the unifying tendency of philosophy; and a more scientific range of thought was required, adapted to reconcile and combine their opposite conclusions. Such a view could only be presented by logical or dialectical investigations, which, from the nature of science itself, might show that it is essential to the completeness and perfection of science that it should embrace both nature and reason at once. It is this perception of the unity of science which constitutes the characteristic of Socrates as a philosopher. In all the accounts of him which either Xenophon or Plato furnish, we invariably discern the attempt, at least, to embrace every question within the light of universal science; and to prove that every species of knowledge, if legitimate, can be pointed out and shown to be a necessary member of the general idea of science.

It was not the object of Socrates to establish any perfectly evolved system of doctrine, so much as to awaken by his discourses a new and more comprehensive pursuit of science, which, no longer one-sided and confined to special branches of enquiry, but convinced of its universality, should direct itself to all that is knowable. But beneath this conviction of the universality of science, and the oneness of its object-matter, we distinctly trace that division of the latter into dialectics, physics, and ethics, which his successors more distinctly established. To these heads, therefore, without expressly ascribing them to Socrates, it will be convenient, for the purpose of classification, to refer his several doctrines.

Under the head of *dialectics*, we have, on the testimony of Aristotle (*Met.* xiii. 4), to ascribe to Socrates two of the very first principles of science—the inductive method of proof, and the definition of ideas. [Ethics.] The object which Socrates had in view by the latter was by the definition of ideas, to determine what the thing is in itself, or its essence. As to the former, we are told by Xenophon that when Socrates wished to come to a decision on any point, his investigations proceeded from propositions generally received as true.

Another feature of the Socratic method was to place the particular idea to be examined in a great variety of combinations; a procedure which implied that every particular thought must, if it contain any degree of certainty, maintain its validity under every possible combination. Such was the true Socratic method of dialectics, which derived its name from the *form* of dialogue (διαλέγειν) in which it was accidently worked out; while, on the other hand, the term *Socratic method* has, in modern times, been confined to signify nothing more than this outward form of arguing by question and answer, to the exclusion of its essential characteristics. Socrates, indeed, did not evolve any systematic doctrine of the form and subject-matter of science. He was satisfied with enforcing on his disciples the pregnant truth, that the legitimacy of every branch of knowledge must be tested by its agreement with all others; and that every thought of man must give an account of itself, and have its root in a knowledge of his own and the divine nature.

This knowledge was the end of his physical enquiries, which were based on the general

principle that all the objects of nature are only so far worthy of enquiry as they exhibit traces of intelligence and design. The self-knowledge which the Delphian oracle had enjoined upon him, Socrates held to be impossible, while man is ignorant of the universal principle whence are the issues of all things. In order to oppose the atheism which prevailed in his day, Socrates examined the causes of the existing unbelief, and referred to the proofs of divinity which the wise order of natural things exhibits. As the prevailing scepticism had its origin in the denial of whatever is unseen and imperceptible to the outward senses, he argued that the soul, which is the ruling principle within man, is yet not discernible; but still its existence is admitted, and it participates in the divine nature. Whoever, therefore, can get rid of the weak desire of seeing the Deity under some palpable form, may easily recognise his operations within his own mind, where God has implanted a consciousness of His presence. But he further held, that not only man, but the whole universe, is under the rule of an intelligent governor; that all is formed for some wise end, and affords evidence of that supreme reason from which man's rational soul derives and has its being. In the consideration of individual things, not less than of the universe, the sole question with Socrates was to establish intelligence as the ruling principle of all. This affords no explanation of his low estimate of the existing physiology. His contempt for it was grounded on the same reason as Bacon's aversion for the schoolmen; and he laboured to show that reason is above nature, and that the natural is merely subservient to intellectual ends. Whatever is without reason is contemptible; and the corporeal is of no value except so far as it ministers to the rational soul. Into the nature of the divine essence he did not enquire, but was content with asserting the principle, that the Deity is the supreme reason, and must be honoured by man as the source of all things, and of all phenomena, and of the end of all human endeavours. Lastly, from the divinity within man, the intelligence visible in the universe, and the worthlessness of body, except as an instrument of reason, Socrates deduced the immortality of the soul as a necessary consequence. (Grote's *History of Greece*, part ii. ch. lxviii.; Sir G. C. Lewis *On the Astronomy of the Ancients*, 112, 175, &c.)

Of the actual teaching of Socrates we can form an idea only by a critical comparison of the various accounts left to us by his admirers or disciples. Socrates himself, spending his life in public, and engaged in endless dialectical disputations, wrote nothing, and although the pictures given in the *Memorabilia* of Xenophon and in the Platonic dialogues are in some main features accordant, they exhibit also many points of unlikeness. On the whole, the portrait, as drawn by Xenophon, a man of no profound science or strong imagination, may be regarded as more nearly historical than the pictures presented to us by Plato, the builder up of a vast framework of philosophy, whether systematised or unsystematised. Thus, our nearest information about Socrates comes to us at second hand, and, as generally in such cases, we have stronger grounds for drawing certain negative conclusions than for maintaining a positive position as to the extent of his teaching. Even if it be granted that all the Platonic dialogues in which Socrates is introduced are reports of actual conversations, it is very doubtful whether a deep philosophical meaning is to be sought or was designed to be set forth in all alike. Many of them are professedly designed for the instruction of youths and children, and apparently rather play on the meaning of words than attempt a genuine search for truth whether of facts or ideas. This popular and unscientific character Dr. Whewell has pointed out (*Fraser's Magazine*, April 1866) in the dialogue entitled, *Lysis, or Friendship*, in which Socrates, by playing on various senses in which the word philos, *friend*, is used, seeks to rouse the boy's attention, and by the exaggerated moral that, if we are wise, everybody will trust us with everything, to lead him to the genuine desire of knowledge, the foundation of all virtue. The conversation with Menexenus is of precisely the same kind; and if it is to be called a dialogue of search at all, it is a search simply for the meaning of a word, and not for a real acquaintance with facts, a method by which, in Dr. Whewell's words, 'moral truth never has been obtained.'

There seems to be some historical evidence for the conclusion that some of these unscientific dialogues were published during the lifetime of Socrates. The Platonic dialogue entitled *Meno* seems to be derived from materials furnished by Simon, a harness maker, in whose shop Socrates held frequent disputations. In this conversation, Anytus, the chief accuser of Socrates, is represented as blaming Socrates not for corrupting the Athenian youth (an accusation here confined to the other SOPHISTS), but for charging the most distinguished Athenians with neglecting the education of their sons, 'precisely the topic dwelt upon in Simon's record of Socrates' conversation.' Anytus is also made with a certain good will to advise Socrates to be on his guard, as it was easy to injure a man at Athens—a statement not likely to be published 'after the result of Anytus's accusation had filled all the friends of Socrates with horror.' So, again, in the *Laches*, the Athenian general Nicias, who was put to death in Sicily in B. C. 413, is introduced as taking part in the debate; and in the *Theages* the result of the expedition of Thrasyllus into Ionia, which ended in his defeat in B. C. 406, is spoken of as still uncertain. The conclusion which Dr. Whewell reaches is that several of the shorter dialogues, as the *Laches*, *Charmides*, *Lysis*, *First Alcibiades*, *Rivals*, *Theages*, and *Meno*, were written before his trial, while one, the *Euthyphro*, was written and published during the trial of Socrates.

On the other hand, the belief that the *Apology* is the actual defence made by Socrates

before the dicasts, stands apparently on very slender foundations. Mr. Grote and Dr. Thirlwall hold that it represents the speech really made at his trial, while Dr. Whewell adopts the opinion anciently avowed by Dionysius of Halicarnassus, 'that it is a composition of Plato, intended, indeed, to defend and exalt Socrates, but also to condemn the Athenian people for putting him to death. Dionysius speaks of it as an encomium in the form of an apology, and in proof of his assertion that it 'certainly never saw the door of a court of justice or an assembly of the agora, being written with another purpose,' Dr. Whewell urges that 'the picture of a philosophical life, such as Socrates describes his to have been, seems more likely to have been written by a philosophical disciple like Plato than to have been delivered before a court of justice,' while the detailed reference to the *Clouds* of Aristophanes, a play then twenty-four years old, 'seems to be fitted rather for a literary and philosophical than for a judicial tribunal.' The argument used by Socrates, 'that it is better for everyone to live among good men than bad, and that therefore he could not have willingly tried to make his neighbours bad men, as Meletus accuses him of doing, would not be likely to avail much in the case of a criminal accusation. Finally, in Dr. Whewell's opinion, the prediction with which the apology ends, rather exhibits Plato prophesying what Plato would, than Socrates describing what Socrates had done. The *Crito* both Dr. Whewell and Mr. Grote agree in regarding as a rhetorical composition, and not as the record of a conversation actually held by Socrates between the passing of his sentence and its execution.

Hence, we cannot without great imprudence ascribe to Socrates himself many of the doctrines or opinions put into his mouth by Plato. In the second book of his *Politics*, Aristotle enters into an elaborate refutation of the alleged Socratic position that society should be based on a community of goods, women, and children; but we cannot get further, historically, than the fact that Plato ascribes this theory to Socrates. The same kind of uncertainty, though in a less degree, hangs over the account of the *Daimonion* or heavenly voice, which, it is stated, Socrates had heard even from his childhood, interfering, when he was about to act, in the way of restraint but never of instigation. There is seemingly no evidence that Socrates spoke of this Daimonion as an attendant peculiar to himself, and even according to the representations of his disciples he never spoke of it as anything grand or awful, or entitling him to peculiar deference (Grote, *History of Greece*, part ii. ch. lxviii.), and there is at least room for the conclusion that by the word he signified simply the conscience, in the sense of the divine voice which spoke in the hearts of other men as in his own. But the fact is beyond dispute that Socrates stands alone amongst the citizens of Athens and other Greek states, as having in his mature years abandoned his profession as a statuary, and devoted himself, as one charged with a divine mission, to the task of teaching men, by convincing them of their ignorance, never withholding his conversation from any, and taking reward from none. If his theory that virtue is knowledge states a part for the whole, and contains defects which may naturally give rise to such charges as were actually brought against him, he yet remains, in Mr. Grote's words, 'the first of ethical philosophers, a man who opened to science both new matter, alike copious and valuable, and a new method, memorable not less for its originality and efficacy than for the profound philosophical basis on which it rests.' (*History of Greece*, part ii. ch. lxviii.)

Sod (Dutch zoode). The grassy surface of the soil pared off with a portion of the earth; in other words, turf.

Sod-burning. Burning of turf taken from the surface of worn-out pasture lands for the sake of the ashes as manure, &c.

Soda (Ger. sode, Span. soda, *natron*). *Mineral alkali; sodic oxide.* This substance is the chief oxide of the metal sodium. It may be prepared by heating sodium in contact with dry air, or by placing sodium in contact with fused hydrate of soda. Soda in the hydrated condition is formed when the metal is placed in contact with water: hydrogen is evolved, and the metal fuses by the heat produced. In this operation 23 parts of sodium evolve 1 part of hydrogen, and the solution contains 40 parts of hydrate of soda, which may be obtained in the pure state by evaporating the solution to dryness and fusing the residue. This hydrate contains 1 atom of sodium, 1 of hydrogen, and 2 of oxygen, and cannot be decomposed by heat alone into water and soda. The principal source of sodium compounds is common salt, or chloride of sodium. This compound is found in very large quantities in nature, both in solution in sea-water and in the compact condition as rock salt. To make it available for the manufacture of sodium compounds, it is converted into carbonate of soda by a process invented by Leblanc. The chloride is treated with sulphuric acid by which it is converted into sulphate of soda, hydrochloric acid being evolved, which is condensed in water. [MURIATIC ACID.] The sulphate of soda or salt cake is next mixed with a quantity of small coal and chalk or limestone, and the mixture heated in a reverberatory furnace. The coal reduces the sulphate of soda to the state of sulphide; double decomposition then takes place between the sulphide of sodium and carbonate of lime, carbonate of soda being produced together with sulphide of calcium, which unites with some of the lime from the carbonate, producing insoluble oxysulphide of calcium. The carbonate of soda is next separated from the residue by extraction with water, and from the solution so formed it is obtained crystallised. Carbonate of soda forms large rhombo-prismatic crystals, containing 31

parts of soda, 22 of carbonic acid, and 90 of water. The crystals effloresce when exposed to air, and at about 150° Fahr. they fuse in their water of crystallisation, which may be entirely expelled by the further action of heat. This salt was formerly obtained exclusively from the ashes of marine vegetables, but this source is now entirely superseded by the process of Leblanc. The carbonate is converted into the hydrate of soda by boiling its solution with slaked lime: it is much used in the arts and manufactures. The *sodium salts* are prepared by the action of the respective acids on the carbonate or hydrate of soda. When chlorine is passed into a dilute solution of soda, a valuable disinfectant and bleaching agent, called *eau de Labarracque*, is obtained. Sulphate of soda, or Glauber's salt, forms crystals containing 71 parts of dry sulphate to 90 of water. The crystals effloresce in the air, and the solution exhibits the phenomenon of supersaturation.

The name *soda* is also often incorrectly applied to commercial crystallised carbonate of soda.

Soda Alum. A hydrated sulphate of soda and alumina. It occurs native in fibrous crusts with a glossy internal aspect, about the Solfatara, near Naples [SOLFATARITE]; in the island of Milo; and at St. Juan, near Mendoza, in South America.

Soda Table-spar. A variety of Pectolite found at Kilsyth, in Stirlingshire.

Soda Water. This common beverage is, as usually prepared, a supersaturated solution of carbonic acid gas in water. *Soda water* properly called, consists of one, two, or three drachms of carbonate of soda, dissolved in a pint of water highly impregnated with carbonic acid. This is often a valuable remedy; but it would sometimes be attended by mischievous results, if indulged in to the extent which some persons pursue the use of soda water. The mere aqueous solution of carbonic acid, which is made by forcing the gas into water by a condensing pump, and under a pressure of six or eight atmospheres, is an agreeable and generally speaking harmless diluent.

Sodalite. A silicate of alumina and soda, with chloride of sodium. It generally occurs crystallised in rhombic dodecahedrons, also massive. In Greenland it is found of a green colour: in the Breisgau, massive, of a grey colour in trap rock; at Vesuvius in large white dodecahedral crystals.

Sodium. The metal contained in soda. It is now manufactured on a large scale by submitting an intimate mixture of carbonate of soda and charcoal to a very intense heat in retorts. The sodium distils over, and is run into ingot moulds. Sodium is a silver-white metal, which is soft at ordinary temperatures and melts at 95·6° Fahr. It rapidly decomposes water, and is used for the extraction of aluminium and magnesium.

Sodium-ethyl. A Chemical compound, having intense affinity for oxygen, and containing the radicals sodium and ethyl. Its combination with carbonic acid results in the formation of propionate of soda.

Soffit. [ARCH; LACUNAR.]

Sofi. A Persian word employed to designate religious persons, otherwise termed *dervishes*. It is probably a corruption of the Greek sophos, *wise*. Sofi was the surname borne by the ancestors of the kings of Persia of the race preceding that which now occupies the throne; and Shah Ismael Sofi, the first monarch of that race, also bore it; hence by European writers of the sixteenth and seventeenth centuries it was used erroneously as a title of the king of Persia.

The tenets peculiarly denoted from these persons by the name of Sofism or Sufism are those of a sect which is said to be gaining ground extensively in Oriental countries, especially among the educated classes of Mohammedans. These tenets, like those of the Quietists and other Christian sects of mystics, are founded on a notion of the union of the human soul with the divinity by contemplation and the subjugation of the appetites; but, as has been too frequently the case among Christians also, they have afforded a cover for refined debauchery. The principles of Sufism appear also to have a remarkable affinity, in some respects, with those pantheistic notions which are prominent in the system of the Brahmans, and seem to form the very foundation of the still more widely extended religion of Buddha.

Sofism. [SOFI.]

Soft Coal. A name for the softer kinds of common or pit coal which break with a woody fracture, and of which most of the coals of Derbyshire and Staffordshire are composed. The term *soft coal* is also synonymous with CHERRY COAL.

Softening. In Painting, the blending of colours into each other. [SFUMATO.]

Soil (Fr. sol, Lat. solum). Earthy and other substances in a state of mixture with organised matter fit for the growth of plants. The surface of the earth in every country on which plants have grown and decayed is properly denominated *soil*; while the earth at a foot or more beneath the surface, commonly called *subsoil*, is comparatively without organised matter, and is therefore properly denominated earth, clay, sand, gravel, lime, or mixed earth, rocks, or stones, as the case may be.

Soirée (Fr. *evening*). This term, originally given by the French to certain evening parties held for the sake of conversation only, has been since introduced into all the languages of modern Europe, and is now employed as a common designation of evening parties in which ladies and gentlemen are intermixed, whatever be the amusements introduced. It is frequently applied in England to the public meetings of certain societies held for the advancement of their respective objects, at which refreshments are dispensed during the intervals of business.

Soke (A.-Sax. soc). A territorial division, now subsisting in Lincolnshire. This term, according to the etymology given by Bracton, designated a precinct in which a particular lord exercised justice. [SOCAGE.]

Sol. In Heraldry, anciently used to denote *or* in emblazoning arms.

SOL. In Music, the French and Italian name for the note of the gamut corresponding to our G.

Sol in its Splendour. In Heraldry, when the sun is figured, i.e. delineated with a human face, and surrounded with rays.

Solanaceæ (Solanum, one of the genera). A natural order of herbaceous or shrubby perigynous Exogens, inhabiting all parts of the world excepting the Arctic regions. They are chiefly known from *Scrophulariaceæ* by their curved or spiral embryo, the plaited æstivation of their flowers, and by the flowers being usually regular, with the same number of stamens as lobes. The first of these characters, however, is not of universal importance; the plaited corolla and symmetrical flowers are better marks of distinction. This order contains Nightshade, Henbane, Mandrake, Tobacco, Stramonium, the Potato, and the Tomato, the leaves of all which are narcotic and exciting, but in different degrees, from *Atropa Belladonna*, which causes vertigo, convulsions, and vomiting, tobacco, which will frequently produce the first and last of these symptoms, henbane and stramonium—down to some of the Solanum tribes, the leaves of which are so inert as to be used as kitchen herbs. Even in the potato plant, the narcotic acrid principle is found in the stem and leaves, and in the rind of the tuber; but the principal part of the latter consists of starch, and the small quantity of deleterious matter being volatile and near the surface, is readily driven off by the heat used in cooking. They are distinguished in the Solanal alliance by their five free stamens, axile placentæ, and terete embryo.

Solania. The active principle of the *Solanum Dulcamara*, or Woody Nightshade, and other species of *Solanum*; it is the ingredient which renders greened potatoes deleterious, being formed in the tubers by the action of light. It is a white alkaloid substance, insoluble in water, but soluble in alcohol, and is highly poisonous, one grain dissolved in dilute sulphuric acid having been found sufficient to kill a rabbit in six hours. Its combinations with the acids are bitter. It is also called *Solanine* or *Solanina*.

Solanine. [SOLANIA.]

Solano. A hot oppressive wind which occasionally blows in the Mediterranean, and particularly on the eastern coast of Spain. The solano is a modification of the sirocco.

Solanum (Lat. *nightshade*). A very extensive genus of plants typical of the *Solanaceæ*. They comprise plants of most varied aspect, some weedy, others ornamental, and some few useful. Some are herbs, some shrubs, and some small trees with lateral or terminal inflorescence. The inflorescence, indeed, in the first instance is always terminal, but in course of growth it becomes bent downwards to give place to a shoot, which is given off from the side of the stem lower down, so that there is a reciprocal change in the direction of the shoot and of the inflorescence. In this way the seeming anomaly of an inflorescence placed on the side of the main stem, and not axillary to a leaf (frequently not even opposite to one), may be explained.

The most important species is *S. tuberosum*, the well-known Potato, of which the underground stems or tubers are in general use as an esculent. They are to be met with everywhere in Europe, and form a principal part of the food of a large proportion of its inhabitants. The plant is regarded as indigenous to Chili and Peru. Its introduction into Europe is ascribed to certain colonists sent from this country to Virginia in 1586, under the auspices of Sir Walter Raleigh. Some authors, indeed, affirm that it was first introduced into Europe by Sir John Hawkins, in 1545; others, that it was introduced by Sir Francis Drake, in 1573; while others, again, maintain that it was for the first time brought to England from Virginia by Sir Walter Raleigh, in 1586. But this discrepancy seems to have arisen from confounding the common Potato (*Solanum tuberosum*) with the Sweet Potato (*Batatas edulis*). The latter was introduced into Europe long before the former, and it seems most probable that it was the species brought from New Granada by Hawkins. Sweet potatoes require a warm climate, and do not succeed in this country; they were, however, imported in considerable quantities, during the sixteenth century, from Spain and the Canaries, and were supposed to have some rather peculiar properties. The kissing comfits of Falstaff, and such like confections, were principally made of batatas and eringo roots. There is reason to think that we are really indebted for the Potato (as well as for tobacco) to Sir Walter Raleigh, or the colonists whom he had settled in Virginia. Gerarde, an old English botanist, mentions in his *Herbal*, published in 1597, that he had planted the Potato in his garden at London about 1590; and that it succeeded there as well as in its native soil, Virginia, whence he had received it. Potatoes were at first cultivated by a very few, and were looked upon as a great delicacy. In a manuscript account of the household expenses of Queen Anne, wife of James I., who died in 1618, and which is supposed to have been written in 1613, the purchase of a very small quantity of potatoes is mentioned at the price of 2*s.* a pound. The Royal Society, in 1663, recommended the extension of their cultivation, as a means of preventing famine; but down to the year 1684 they were raised only in the gardens of the nobility and gentry. In that year they were planted, for the first time, in the open fields in Lancashire—a county in which they have long been very extensively cultivated.

Potatoes, it is commonly thought, were not introduced into Ireland till 1610, when a small quantity was sent by Sir Walter Raleigh, to be planted in a garden in his estate in the vicinity of Youghal. Their cultivation extended far more rapidly than in England; and they have long furnished from three-fifths to four-fifths of the entire food of the people of Ireland! Potatoes were not raised in Scotland, except in gardens, till 1728, when they were planted in the open fields by a person of the name of Prentice, a day labourer at Kilsyth, who died at Edinburgh in 1792.

The extension of the Potato cultivation has been very rapid during the last half-century. The quantity now raised in Scotland is supposed to be from ten to twelve times as great as the quantity raised in it at the end of the American war; and though the increase in England has not been nearly so great as in Scotland, it has been greater than during any previous period of equal duration. The increase on the Continent has been similar. Potatoes are very largely cultivated in France, Italy, and Germany; and, with the exception of the Irish, the Swiss have become their greatest consumers. They were introduced into India some sixty or seventy years ago, and are now successfully cultivated in Bengal; they have also been introduced into the Madras provinces, Java, the Philippines, and China. But the common potato does not thrive within the tropics, unless it be raised at an elevation of 3,000 or 4,000 feet above the level of the sea, so that it can never come into very general use in these regions. This, however, is not the case with the sweet potato, which has also been introduced into tropical Asia; and with such success, that it already forms a considerable portion of the food of the people of Java, and some other countries. So rapid an extension of the taste for, and the cultivation of, an exotic, has no parallel in the history of industry: it has had, and will continue to have, the most powerful influence on the condition of mankind.

The Potato consists of a mass of cells, enclosing starch-granules and an albuminous juice. The chemical composition of the Potato is subject to great variations, as the analyses of different chemists vary considerably. In general terms, it may be stated that Potatoes contain water in quantity amounting to three-fourths of their weight, the remaining fourth part being made up of starch, gum, sugar, albumen, vegetable fibre, and a very small proportion of fatty material. Potatoes in cultivation are subject to various diseases, the most important and disastrous of which is one which first made its appearance (at least as a widely spread malady) in 1845. This potato-murrain appears, from the researches of the Rev. M. J. Berkeley and others, to be due to the presence of a fungus, *Botrytis* (or *Peronospora*) *infestans*, which first attacks the leaves, causing a discoloration of them, and thence rapidly spreads down the stems to the tubers. The principal effects of the disease consist in the increased quantity of water, the diminished quantity of starch, and the conversion of the albumen into casein. Owing to the almost entire dependence of the Irish peasantry on this vegetable for food, the most disastrous consequences ensued from the failure of this crop; and it is still heartily to be wished that one of a less precarious nature should be grown, and one which would furnish a larger percentage of nutritious matter than the Potato. Numerous substitutes have been proposed and tried, but time is required to combat the prejudice in favour of the Potato, and to develope sufficiently the capabilities of the proposed substitutes.

Potatoes furnish a large quantity of starch, which is employed for various purposes in the arts. It forms the basis of certain farinaceous foods, as Bright's Nutritious Farina, &c., and is mixed with wheaten flour in the manufacture of bread. This adulteration can readily be detected by the microscope, especially on the addition of a solution of potash, which causes the starch granules of the potato to swell up, while no effect is produced on the starch-grains of wheat. From potato-starch is also procured a substance analogous to gum, called *dextrine*, and which is employed as a substitute for gum, size, and paste. The pulp of the Potato, after the extraction of the starch, becomes hard and horny when dried, and is used in the manufacture of snuffboxes, &c. Raw potatoes scraped are used as a popular cooling application to burns and scalds. From Potatoes a coarse-tasted brandy is prepared in large quantities on the Continent. The stem and leaves have slightly narcotic properties, on which account the extract from them has been employed as a narcotic to allay pain in cough and rheumatism, &c. Potatoes when decaying have been stated to emit a phosphorescent light, but this requires confirmation. As a vegetable, the Potato is excellent in whatever way it may be dressed—whether plain boiled, steamed, fried, or roasted. With the flour of potatoes puddings and cakes have been made; starch has also been obtained, which for purity and nutritive properties is very little inferior to arrowroot. The usefulness of the potato was remarkably shown by M. Parmentier, who did so much in France to promote its cultivation towards the end of the last century, and who gave a grand entertainment, at which Benjamin Franklin, Lavoisier, and many other celebrated men of that day were present. Every dish consisted of potatoes dressed in an endless variety of form and fashion; and even the liquors were the produce of this precious root.

S. esculentum and its varieties furnish the fruits known as Aubergines, which are highly esteemed in France, and may occasionally be met with in Covent Garden Market; they are of the size and form of a goose's egg, and usually of a rich purple colour. The Egg-plant, which has white berries, is only a variety of this. The Peruvians eat the fruits of *S. muri-*

catum and *S. quitense*; those of *S. ramosum* are eaten as a vegetable in the West Indies. The Tasmanian Kangaroo Apple is the fruit of *S. laciniatum*; unless fully ripe, this is said to be acrid. In Gipps' Land, Australia, the natives eat the fruits of *S. vescum*, which, like the preceding, is not agreeable till fully ripe, when it is said to resemble in form and flavour the fruits of *Physalis peruviana*. The fruits of *S. album* and *S. æthiopicum* are used in China and Japan. Those of *S. Anguivi* are eaten in Madagascar. Of other species the leaves are eaten: as those of *S. oleraceum* in the West Indies and the Feejee Islands, of *S. sessiliflorum* in Brazil, of *S. nigrum* in the Islands of Bourbon and Mauritius, &c.

Some species are employed as dyes. Such is *S. indigofera*, cultivated in Brazil for the sake of its indigo. The juice of the fruit of *S. gnaphalioides* is said to be used to tint the cheeks of the Peruvian ladies, while their sisters of the Canary Isles employ for a similar purpose the fruits of *S. Vespertilio*. The fruits of *S. saponaceum* are used in Peru to whiten linen in place of soap. *S. marginatum* is employed in Abyssinia for tanning leather. [LYCOPERSICUM.]

Solar. In Mediæval Domestic Architecture, a chamber built over the cellar at the back of the daïs of the great hall, or, in later buildings, over the hall itself. (*Domestic Architecture in England from Richard II. to Henry VIII.* part i. ch. iii.)

Solar Cycle. A period of twenty-eight years. [CYCLE.]

Solar Phosphori. Substances which are seen to be luminous in a dark place after having been exposed to light. Calcined oyster shells are a good example.

Solar System. The Solar System, in Astronomy, consists of the sun, and all the celestial bodies whose motions are controlled by its gravitation, viz. the planets, satellites, and comets. Under the words ASTRONOMY; COMET; COPERNICAN SYSTEM; HELIOCENTRIC SYSTEM; METEORS, LUMINOUS; PLANET; PTOLEMAIC SYSTEM; SATELLITE; and SUN; we have referred to the different explanations of celestial phenomena, which have been given from time to time, and have entered into details regarding the different bodies of which our system is composed. We may regard that system from the most general point of view, as a type of those which probably are feebly indicated to us in the light of every star; and now that the complete similarity of our sun to the other bodies of the sidereal universe in the broader physical features has been established by the spectroscope, the mind without difficulty seizes the idea. The dimensions of our sun are enormous merely in consequence of its proximity to us, and if it be not a coloured star it is probably a variable one. We may fairly assume, therefore, that other systems are not vastly dissimilar from our own, except perhaps in the life conditions which obtain at the present epoch. The number of bodies which compose the system as at present known is as follows:—

1. The central Sun—the primary.
2. Ninety-three planets, including eighty asteroids.
3. Eighteen satellites or tertiary bodies.

The sun and planets will be found elsewhere described. The minor planets which circulate between Mars and Jupiter are as follows (arranged in the order of discovery):—

1	Ceres	45	Eugenia
2	Pallas	46	Hestia
3	Juno	47	Aglaia
4	Vesta	48	Doris
5	Astræa	49	Pales
6	Hebe	50	Virginia
7	Iris	51	Nemausa
8	Flora	52	Europa
9	Metis	53	Calypso
10	Hygieia	54	Alexandra
11	Parthenope	55	Pandora
12	Victoria	56	Melete
13	Egeria	57	Mnemosyne
14	Irene	58	Concordia
15	Eunomia	59	Olympia
16	Psyche	60	Echo
17	Thetis	61	Danaë
18	Melpomene	62	Erato
19	Fortuna	63	Ausonia
20	Massilia	64	Angelina
21	Lutetia	65	Maximiliana
22	Calliope	66	Maia
23	Thalia	67	Asia
24	Themis	68	Leto
25	Phocea	69	Hesperia
26	Proserpine	70	Panopea
27	Euterpe	71	Niobe
28	Bellona	72	Feronia
29	Amphitrite	73	Clytie
30	Urania	74	Galatea
31	Euphrosyne	75	Eurydice
32	Pomona	76	Freia
33	Polyhymnia	77	Friga
34	Circe	78	Diana
35	Leucothea	79	Eurynome
36	Atalanta	80	Sappho
37	Fides	81	Terpsichore
38	Leda	82	Alcmene
39	Lætitia	83	Beatrix
40	Harmonia	84	Clio
41	Daphne	85	Io
42	Isis	86	Semele
43	Ariadne	87	Sylvia
44	Nysa	88	Thisbe

Other integral portions of the system are the meteoric rings lying near the earth's orbit

[METEORS, LUMINOUS], and possibly others, the existence of which is suspected in other portions of the system. [COMET; ZODIACAL LIGHT.]

Both physicists and geologists are now agreed that the earth was once in an incandescent state, a condition of things probably represented to us at the present time, in kind if not in degree, by our sun. We are therefore justified in assuming that the rest of the planetary family were once in the same condition; hence it is extremely unlikely that, taking their masses and positions into consideration, they present at the present time the same life conditions as the earth. The verdict of the telescope is precisely in the same direction. Hence much that has been advanced without taking these facts into consideration will require to be modified in the light of modern enquiry.

It is difficult to accept the present terrestrial conditions as merely *accidental*, but if it can no longer be doubted that our globe was once an incandescent body and a sun pro tanto, so also a time will come when, as a remote consequence of the further dissipation of its energy, it will again become unfit for the abode of beings similar to those which now inhabit it. If we accept the evidence furnished by the other planets, we are almost driven to this conclusion. Jupiter and Saturn may be worlds —as far as life conditions are concerned— younger than our own. Life conditions on Mars we know to be not very unlike our own, if we except gravity; while, according to Frankland, the moon has lost all its internal heat, and probably has exhausted the cycles of life on its surface.

The celestial scenery presented by the different planets is vastly different. The inhabitants of the earth with its one moon, which lights up but a small per-centage of our nights, can scarcely form an idea of the astounding grandeur of the scene that is unfolded in some of the sister planets, from moonless Mercury, with a sun occupying a large portion of the celestial arc, to Neptune, where the same body appears only as a star. Among these various systems, however, that of SATURN stands pre-eminent in its gorgeousness and uniqueness. Not only have we here eight moons performing their circuits in intervals varying from twenty-two hours to seventy-nine days, but a ring system which may possibly consist of millions of satellites in the closest juxtaposition—asteroidal rings capable of reflecting the sun's light, spanning the heavens, now in a complete arch through the zenith, now in a broken one near the horizon, the varying appearances depending upon the latitude of the observer and the position of the planet's shadow on the ring. These same rings give rise to most curious eclipse phenomena. Not only do they at night eclipse the stars, but in certain latitudes they cause eclipses of the sun. 'In latitude 40° we have morning and evening eclipses for more than a year, gradually extending until the sun is eclipsed during the whole day, and then total eclipses continue for nearly 7 years, eclipses of one kind or another taking place for 8 years 292·8 days.'

The celestial scenery in the solar system is, however, in spite of all its variety, vastly inferior to that afforded by the systems which in all probability circulate round the various multiple systems, some of which consist of stars of colours sufficiently distinct to give rise to days of different colours.

Solar Year. The interval between the sun's leaving the first point of Aries and returning to it again.

Soldan. [SULTAN.]

Solder (Fr. souder, from Lat. solidus, *solid*). Plumbers' solder is an alloy of three parts of lead and one of tin; it is more fusible than lead, and readily adheres to clean surfaces of that metal when it is fused. Fine solder is a mixture of two parts of tin and one of lead; it fuses at 360°. Hard soldering, or brazing, by which two surfaces of copper are made to adhere, is done by fusing together brass and zinc. When this solder is used, the copper requires to be highly heated.

Soldier (Low Lat. soldarius; literally, *one who serves for pay*). [SOU.] In general language, a person equipped and maintained by the state for the purpose of defending it from foreign aggression, of putting down intestine commotion, or, in short, of protecting its interests either at home or abroad, according to instructions issued by the existing government. [ARMY; ENLISTMENT, &c.]

Sole of an Embrasure. In Fortification, the bottom of an embrasure.

Sole Piece. In the cradle on which a ship is launched, the sole piece is a plank resting on the bilgeways, and sustaining the lower ends of the poppets on which the weight of the vessel hangs. These poppets have tenons in their lower ends which fit into a groove in the sole piece.

Sole Plate. A strong plate of iron which constitutes the base or foundation of a marine engine, and which is securely bolted to the keelsons of the ship, while the various parts of the engine are bolted to it. In side-lever marine engines the condenser is usually cast upon the sole plate, so as to obviate the necessity of joints in a part of the engine very liable to air leaks.

Solea (Lat.). In Architecture, that part of the Roman basilica which answers to the presbytery in more modern churches.

SOLEA. In Mammalogy, the inferior surface of the foot or hoof.

SOLEA. The name of a genus of flat fishes (*Pleuronectidæ*), characterised as follows: 'Both eyes on the right side; the mouth distorted on the side opposite the eyes; small teeth in both jaws, but confined to the under side only; form of the body oblong; dorsal and anal fins extending to the tail.' The common sole (*Solea vulgaris*, Cuv.) is taken by trolling, and in enormous quantities, along our coasts, principally from Sussex to Devon-

shire; and excepting towards the latter end of February, and the beginning of March, when the soles are spawning and are rather soft and watery, they are in good condition for the table throughout the year.

Solecism (Gr. σολοικισμός, said to be derived from Soli, an Athenian colony in Cilicia, whose inhabitants spoke a barbarous Greek). In Grammar and Rhetoric, a violation of the idiomatic rules of grammar or construction in writing or speaking a language. Quintilian distinguishes *solecism* from *barbarism*, the latter word being applied to the erroneous use of single words.

Solenaceans (Gr σωλήν, *a tube*). The name of a family of Dimyary Bivalve Molluscs, of which the razor shell (*Solen*) is the type; they are distinguished by the great length of the respiratory tubes, whence their name.

Solenoid (Gr. σωληνοειδής, *like a tube*). In Electro-Dynamics, a name given by Ampère to a system of small electrical currents, equal and equidistant, and returning into themselves, the planes of which are normals to any given line, whether a straight line or curve, upon which their centres are situated, and which forms the axis of the *solenoid*. (Despretz, *Traité de Physique*, 1836.)

Solfatara. A volcanic vent from which sulphur and sulphurous and other acid vapours and gases are erupted with much steam.

Solfatarite. A name given to the Soda-alum found at Solfatara near Naples.

Solfeggio. In Music, the system of arranging the scale by the names *ut, re, mi, fa, sol, la, si*, by which musical students are taught to sing, these notes being represented to the eye by lines and spaces, to which the syllables in question are applied. [MUSIC.]

Solicitor. The professional designation of persons admitted to practise in the Court of Chancery in the conduct of suits, &c., who are styled *attorneys* in the courts of common law. [ATTORNEY.] In Scotland, the term *solicitor* is synonymous with *attorney* in England. They are inferior to the *writers to the signet*, and practise in the inferior courts.

Solicitor-General. The *solicitor-general* is an officer of the crown, who holds by patent, and ranks next to the attorney-general, with whom he is, in fact, associated in the management of the legal business of the crown and public offices. He receives some particular fees on pleadings, and on the enrollment of patents, &c.; but the division of business between him and the attorney-general is chiefly regulated by usage founded on convenience. The earliest date at which the name of this officer occurs, so far as is known, is the year 1461. [ATTORNEY-GENERAL.]

Solid (Lat. solidus). In Geometry, a magnitude which has three dimensions—length, breadth, and thickness. The boundaries of solids are *surfaces*, which have only two dimensions—length and breadth; the boundaries of surfaces, again, are *lines* which have but one dimension, length. Lastly, the extremities of lines are *points* which are destitute of all dimensions, and possess position merely.

SOLID. In Physics, the term *solid* is applied to that condition of matter in which the attractive forces of the molecules are greater than the repulsive, and the molecules consequently cohere with greater or less force. The other states of matter are the *liquid*, in which the attractive and repulsive forces are nearly balanced; and the *gaseous*, in which the repulsive prevail.

Solid Angle. In Geometry, an angle formed by the meeting in one point of three or more plane angles, which are not in the same plane. This is Euclid's definition. [ANGLE.] A solid angle may be measured by the area of spherical polygon which it determines on a sphere of unit radius, whose centre is at its vertex. By allowing the plane angles to increase in number and diminish in magnitude, we may extend the conception of a solid angle to that which is formed at the vertex of every cone.

Solid Bodies, Flow of. The thin tubes of block tin, used by painters for holding their colours, are formed by placing a disc of block tin in a die or hollow cylinder, into which cylinder a punch that almost exactly fits it is forced down by appropriate mechanism, and the tin rises into the intervening annulus in the same way as if it were a liquid, its constituent particles being made to move upon one another by the great pressure applied, in much the same way as they would do if the tin were melted by heat. Recently the subject of the flow of solid bodies by the application of great force has been experimentally investigated by M. Tresca; first, by punching a cylindrical hole in a plate; secondly, by the compression of a cylinder in a direction parallel to its axis; and, thirdly, by compelling the efflux of solid materials from a cylindrical chamber through an orifice in the side or bottom. In the ordinary flow of liquids, the compelling force is gravity, which, however, is not sufficient to move the particles of all bodies upon one another. But there is no reason to doubt that solids equally with fluids will be made to conform to hydrostatic laws, if instead of gravity we use some other force which shall be proportionate in amount to the resistance which has to be overcome.

The first experiment of M. Tresca was made in punching a block of lead, composed of sixteen plates superimposed on one another. The plates were four millimètres, or about one-sixth of an inch, in thickness, their total height being sixty-four millimètres, or about two and a half inches. They were firmly held together by iron plates at the top and bottom, in each of which plates a hole of twenty millimètres was made, through which a punch of that diameter could pass. The punch was propelled through the lead by hydraulic power, and a punching was extruded of twenty millimètres diameter and thirty-one millimètres high. Now, as it was found that the specific

gravity of the lead punched out had not been changed, the question arose, what became of the other thirty-three millimètres in the height of the column? To determine this, the punched block was cut through, and the cut surface carefully planed; and it was found, that while the top layer and the three bottom ones retained their original thickness, the thickness of the intermediate layers was considerably reduced, and it appeared that much of the metal in the early part of the punching escaped sideways, in a way similar to that in which a liquid would escape, that being the line of least resistance during the early part of the operation.

It was further found, on examining a section of the punching by a microscope, that the punching of each succeeding plate was dished over the preceding one, so that the dished edges of the whole sixteen layers could be traced from top to bottom of the punching only vastly reduced in thickness. In punching layers of wrought-iron plates, similar results have been observed.

M. Tresca's second experiment consisted in the compression of a cylindrical block of lead, 60 centimètres diameter, formed by placing twenty discs upon one another, the collective height being 63 millimètres. The block was compressed until its height became 18 centimètres; and its diameter was then found to be increased to 110 millimètres in the middle of the block, and 103 and 105 millimètres at the ends. It was found on examination that the upper and lower plates had hardly changed their dimensions, whereas the middle plates had not only become thinner but had dished themselves outwards so as to enclose the others and to form the exterior surface of the block.

M. Tresca next subjected two circular plates of lead 3 millimètres thick and 4 inches diameter to compression between two iron discs, one of which had a hole ·8 inch diameter in its centre. In all those parts of the plates pressed by the iron disc, they were reduced by compression to ·08 in thickness, and the lines of the layers were parallel in this part. The lead flowed out both by the circumference and through the central hole in a jet of metal which assumed the figure of the contracted vein, but the jet instead of being solid was hollow, a result imputed to the circumstance that the particles are acted on by two forces, the one being hydrostatic pressure and the other cohesion. M. Tresca has subjected to mathematical investigation the laws proved by his experiments to be in operation in regulating the flow of solids under compression, and has deduced formulæ which represent the facts with accuracy, and which constitute the elements of a new theory of the strength or resistance of materials. The processes of planing and turning, cutting, hammering, and rolling, and, in fact, nearly all the mechanical processes for moulding materials practised in the arts, are illustrations of the principle which M. Tresca has brought to light, and which appears destined to overturn some of the accepted foundations of some departments of physical science.

Solid Problem. A solid problem formerly denoted one which could not be constructed by the intersections of circles and straight lines, but whose geometrical construction required the description of one or more conic sections. The algebraic solution of a solid problem leads to a cubic or biquadratic equation. Problems which admitted of being constructed by the intersection of two circles, or of a straight line and circle, were called *plane problems*; they give rise to equations of the second degree.

Solidity (Lat. soliditas). Like many other mechanical terms, this term is not easily defined with exactness. Fortunately, its popular definition is unnecessary, inasmuch as everyone must be familiar with the particular condition of matter to which it is applied. It occurs when the cohesion of particles of matter is so great that mere gravity is insufficient to cause them to move freely over one another, as is the case in liquids and gases.

Solidungulates (Lat. solidus, and ungula, *a hoof*). The name of a tribe of Mammals, including those with only a single hoof on each foot: as the horse, ass, &c.

Solifidian (Lat. solus, *alone*, and fides, *faith*). A name sometimes applied to those who maintain that men are justified by faith only without reference to works.

Soliloquy. [Monologue.]

Solipeds. [Solidungulates.]

Solitaries. [Anchorites; Hermits.]

Sollecito (Ital. *anxious*). In Music, a term denoting that the movement to which it is affixed is to be performed in a mournful manner. It also means that the music is to be performed carefully.

Solo (Ital. *alone*). In Music, a movement, or part of a movement, in which only one voice or instrument is employed or is especially prominent.

Solomon's Seal. The common name of the *Convallaria polygonatum*, sometimes made the type of a distinct genus, *Polygonatum*.

Solstice (Lat. solstitium). The time at which the sun is at its greatest distance from the equator, and when its diurnal motion in declination ceases. This happens at midsummer and midwinter; or when the sun arrives at the tropic of Cancer and the tropic of Capricorn.

Solstitial Points. Those points of the ecliptic at which the sun arrives at the time of the solstices. They are the first points of Cancer and Capricorn.

Solution (Lat. solutio, from solvo, *I loose*). The force which binds similar masses of matter together is called *cohesion*, that which binds dissimilar masses being termed *adhesion*. When a solid is placed in a liquid, solution results if the adhesion of the solid for the liquid is greater than the cohesion existing among the particles of the solid; but if the cohesion is superior to the adhesion, then the solid is said

to be insoluble. Heat is antagonistic to cohesion, to a far greater extent than it is to adhesion; hence heat generally facilitates solution. When heat is withdrawn from a body, the opposite effect of course takes place; and this explains how crystals and other solid bodies separate out from a hot solution on cooling. A *saturated* solution results when cohesion and adhesion exactly balance each other.

SOLUTION. In Mathematics, the construction of a proposed problem, or the expression of its conditions by an equation which gives the value of the unknown quantity.

Solvent. In Chemistry, the liquid in which a solid is dissolved. The substance dissolved is sometimes distinguished as the *solvend*.

Sombrerite. A new mineral (a phosphate of alumina and lime) remarkable for the large amount of phosphoric acid which it contains. It forms a large portion of some small islands in the West Indies, especially of Sombrero Island, about sixty miles from St. Thomas.

Sombrerite has been used for the preparation of phosphorus and phosphoric acid, and also for the manufacture of artificial manure (superphosphate of lime) for agricultural purposes.

Somervillite. A variety of Melilite, of a dull yellow colour, found in the older ejected lavas on Vesuvius, associated with black mica, &c. It was named by Brooke after Dr. Somerville.

Sommite. A name for Nepheline, given from its occurrence at Monte Somma.

Somnambulism (Lat. somnus, *sleep*, and ambulare, *to walk*). This is a species of dreaming, in which the bodily as well as the mental functions are affected. There are many remarkable cases of this kind on record, some of which would appear perfectly incredible, were they not attested by creditable as well as by competent and scientific witnesses. Somnambulism has been defined as 'a state in which the mind retains its power over the limbs, but possesses no influence over its own thoughts, and scarcely any over the body, excepting those particular members of it which are employed in walking.' Dr. Abercromby, in his *Inquiries concerning the Intellectual Powers and the Investigation of Truth*, observes, in regard to this singular affection, that although the mind is fixed upon its own impressions as in ordinary dreaming, the bodily organs are more under the control of the will; so that the individual acts under the influence of his erroneous conceptions, and holds conversation in regard to them. He is also, to a certain degree, susceptible of impressions from without through his organs of sense; not, however, so as to correct his erroneous impressions, but rather to be mixed up with them. Dr. Abercromby observes, that the first degree of somnambulism generally shows itself by a propensity to talk during sleep; the person giving a full and connected account of what passes before him in dreams, and often revealing his own secrets or those of his friends. Walking during sleep is the next degree, and that from which the affection derives its name. He gets out of bed, often dresses himself, and goes out of doors, walks frequently over very dangerous places in safety; sometimes he gets out of a window, walks along a parapet, gets to the roof of a house, and returns through similar risks to his apartment. On awaking in the morning he is either utterly unconscious of having stirred during the night, or remembers it as a mere dream. These cases are comparatively common; but sometimes the transactions of the somnambulist are carried much further: he will mount his horse and ride, or go to his usual occupations, such as threshing, saddle-making, playing on musical instruments, composing verses, and so forth.

Although somnambulists are generally insensible to anything that is said to them, they are sometimes capable of holding conversation, especially in those cases where the affection occurs, as it sometimes does, in the daytime. In these attacks the individuals are generally unconscious of external impressions, or at all events extremely confused in their notions of external things. They frequently speak intelligibly, holding conversations with imaginary beings, or relating circumstances which were supposed to have been entirely unnoticed or forgotten. Some have been known to sing in a style superior to anything which they could attain when awake; and Dr. Abercromby states that there are some well authenticated instances of persons in this condition expressing themselves correctly in languages with which they were imperfectly acquainted.

Somnus (Gr. Ὕπνος). In Mythology, the god of sleep, the son of Erebus and Nox, or of Nox alone, and brother of Thanatos, *death*. [SARPEDON.]

Son Assault Demesne (Old Fr.). In Law, a plea in an action for an assault, viz. that it was the plaintiff's own original assault that occasioned the violence complained of.

Sonata (Ital. sonare, *to sound*). In Music, an instrumental composition, usually containing three movements, an allegro, a slow movement, and a rondo. Modern sonatas are generally for one or two instruments only, as for the pianoforte, or for the piano and violin.

Sonnet (Ital. sonetto). In Poetry, a short composition of fourteen or fifteen lines, of ten or eleven syllables, rhymed according to an intricate but not always precisely similar arrangement. It is the oldest form in which the Italian language was used; but it was, at a still earlier period, employed, although not commonly, by the Provençal poets. In Italy, Dante and the Tuscan poets his contemporaries brought the sonnet into public estimation, about the beginning of the fourteenth century; but by them it was invariably employed as the vehicle of thoughts wrapped in very obscure language, and probably of a symbolical nature, though generally, in their outward signification, breathing the spirit of romantic and chivalrous love. By Petrarch, in the course

of the same century, the sonnet was carried to perfection in point of form and polish; although applied by him, as it had been by his predecessors, almost exclusively to the subject of his figurative and mystical passion. Since the time of Petrarch the sonnet has been a favourite form of composition in Italy, especially for the purposes of occasional poetry. In France it has had little success; or rather the French sonnet is a different poem, less regular in its construction than the Italian. In England, Milton has given to it a dignity peculiarly his own, together with much of the melody and tenderness which characterises his Italian models. The proper sonnet is divided into two quatrains, with four lines and two rhymes each, and two terzines, each with three lines and a single rhyme. Pieces of a similar metrical structure in octo-syllabic lines are termed by the Italians Anacreontic sonnets. It is sometimes said that there is 'hardly an educated Italian who has not composed a sonnet.'

Sonnites. [SHIAH.]

Soot (A.-Sax. sot). This well-known chimney deposit consists chiefly of fine particles of carbon mechanically carried up from a coal or wood fire. It also contains much mineral matter, the lighter portion of the ash of the fuel; and in addition always yields liquid hydrocarbons, condensed doubtless from unburnt hydrocarbon vapours, together with notable quantities of ammoniacal salts. The latter render soot, especially coal-soot, valuable as a manure.

Soot Coal. A variety of bituminous coal with an uneven earthy fracture. It is found in Scotland.

Soothsayers. [ASTROLOGY; DIVINATION; ORACLE.]

Sophism. [FALLACY.]

Sophist (Gr. σοφίστης, from σοφός, *wise*). A Greek word, originally signifying a person of talent and accomplishments. It was applied to a class of men who arose in Greece in the fifth century B.C., and taught the youth in the principal cities various arts and acquirements for hire. It has hence come to be the general designation of all such as cultivate any branch of science or philosophy with a view to outward advantages, careless of the truth of what they advance, except in so far as it may contribute to those purposes. The first Greek who assumed the name of *Sophist* was Protagoras, a native of Abdera, who flourished about the year 440 B.C., and obtained numerous pupils and auditors, especially in Athens. Of those who followed the same occupation, the most celebrated were Hippias of Elis, Gorgias of Leontium, Prodicus of Ceos, and Euthydemus of Chios, with his brother Dionysiodorus. None of the writings of these men have survived; but we have abundant notices in the writings of their contemporaries, especially Plato, Xenophon, and Aristophanes, of the character of their teaching. On that teaching very different opinions have been entertained; but it is a subject on which a more than ordinary attention to both sides of the controversy is absolutely necessary. Mr. Grote, in his *History of Greece*, part ii. ch. lxvii., has impugned altogether the assertion, that the Sophists were selfish teachers who systematically corrupted the Athenian youth, and maintains that Solon and Pythagoras, Socrates, and even Plato himself were ranked in this class by their contemporaries. He denies that any charge of corruption is brought against Protagoras by Plato, whose opposition to the paid teachers arose 'from the radical difference between his point of view and theirs. He was a great reformer: they undertook to qualify young men to doing themselves credit and rendering service to others in active Athenian life. Plato was also unrivalled as a speculative genius and as a dialectician: and his reforming as well as theorising tendencies brought him into polemical controversy with all the leading agents by whom the business of practical life was carried on at Athens.' (*Ib.* vol. viii. p. 488.) [PLATONISM; SOCRATIC PHILOSOPHY.]

Sophora (Arab. sophera). A genus of *Leguminosæ*, consisting of trees or shrubs found on the seashores of tropical Asia, Africa, America, and Australasia, all having pinnate leaves, and terminal simple racemes or branching panicles of papilionaceous flowers.

S. japonica is a very handsome tree, long ago introduced into the gardens of this country from China; but it is not so frequently grown as, from its ornamental character and hardiness, it deserves to be. It is of quick growth, and forms a large round-headed tree forty feet high or more, in autumn producing at the points of the branches large loosely-branching panicles of small whitish or cream-coloured flowers, which give it a beautiful and conspicuous appearance, though the flowers themselves are small. In China, the flowers are used for dyeing a yellow colour. They are called Wai-fa or Wai-hwa by the Chinese, and are employed to give the fine yellow colour to the silk used for the garments of the mandarins, and also for dyeing blue cloth green. Large quantities of them are thus consumed, the tree being cultivated on this account in the provinces of Fokien, Honan, and Shantung, from whence sacks full of these little flowers are despatched to other parts of the empire. All parts of the tree possess purgative properties, and it is said that even those who merely prune it are affected, as also are turners when employed upon its fine-grained hard wood. The tree is known only in a cultivated state, and its native country is therefore uncertain, though it is most probably indigenous to either China or Japan.

Soporifics (Lat. sopor, *sleep*). Medicines which induce sleep.

Sopra (Ital. *above*). In Music, a term frequently used for description; as *nella parte di sopra*, in the higher or upper part; *di sopra*, above; *contrapunto sopra il soggetto*, counterpoint above the subject, &c.

Soprano (Ital.). The upper or treble part in vocal compositions.

Sorb (Lat. sorbus). The Service-tree, *Pyrus domesticus*.

Sorbic Acid. The acid of the berries of the *Pyrus* (*Sorbus*) *Aucuparia*, or Mountain Ash. It is identical with the *malic acid*.

Sorbonne. A college at Paris for the study of theology; so called from the village of Sorbonne, in Champagne, where its founder, a priest named Robert, was born about the beginning of the thirteenth century. He made a provision for the instruction of sixteen poor clerks in theology, and his college is said to be the first example of what was afterwards the common character of all the English colleges, the institution of a cœnobium for regular clergy. The college of the Sorbonne was adorned with various new edifices and enriched with a library by Cardinal Richelieu, in 1629. (Mosheim, *Eccl. Hist.*) This great college of theology exercised a high influence in ecclesiastical affairs and on the public mind, especially in the sixteenth and seventeenth centuries; insomuch that the sceptical wits of the eighteenth usually employ the name as synonymous with the spirit of bigotry itself. Its proverbial celebrity for acuteness in theological disquisition is attested by the lines of our own Butler:—

> For he a rope of sand could twist
> As firm as learned Sorbonist.

(Hallam, *Literary History*, part iv. ch. ii. § 20, &c.)

Sorcerer (Lat. sortitor, from sors, *a lot*; whence *sorcery*). Properly one who practises sortilege, or divination; but, in the ordinary language of the middle ages, one exercising magical powers, especially by the aid of evil spirits. The *sorcerer* of the middle ages was, generally speaking, a personage of distinction, while the *witch* was degraded and loathsome. Of the species of sorcery which is still practised in the East, especially in Egypt, by means of the magic mirror, the most complete account of it will be found in Lane's *Modern Egypt*. [RATIONALISM; WITCHCRAFT.]

Sordawalite. A variety of Wichtyne, resembling Pit-coal in appearance, found in greyish or bluish-black opaque masses, near Sordawala in Finland, forming thin veins in trap-rock. It is a silicate of alumina, iron, and magnesia, with about three per cent. of phosphoric acid.

Sordini. In Music. [CON SORDINI.]

Soredia (Gr. σωρός, *a heap*). In Botany, heaps of powdery bodies found in lichens lying upon any part of the surface of the thallus.

Sorex (Lat.; Gr. ὕραξ, *a field-mouse*). A Linnæan genus of the order *Bestiæ*, now forming an extensive tribe of Insectivorous Ferines (*Carnassiers*) in the system of Cuvier, and subdivided into different genera. The original generic term is confined to the shrews, or shrew-mice, which are the type of the family (*Soricidæ*), and are characterised by having the two superior middle incisors curved and indented at the base, the two inferior incisors prolonged and procumbent. Behind the upper pair of incisors there are five little conical teeth on each side, and two similar teeth behind the lower pair of incisors: the molars, which are beset with sharp cusps, are four on each side above, and three below. The true shrews are further characterised by lateral, and sometimes anal and femoral, scent glands. The principal genera, now distinct, which would have ranked with the Linnæan *Sorex* are *Myogalea*, *Condylura*, *Tupaia*, *Gymnura*, *Macroscelis*, *Cladobates*, *Solenodon*, *Crossopus*, *Crocidura*. Of these, *Gymnura* belongs rather to the family of hedgehogs, and *Condylura* to that of the moles.

Sorghum (Indian sorghi). A genus of grasses, the species of which are extensively cultivated for food, particularly *S. vulgare*. In Spain, Italy, and other parts of the South of Europe, as well as in Arabia and Asia Minor, this Millet or Guinea Corn occupies a place similar to that which oats and barley hold in the field-culture of the northern parts of Europe. The flour which the round hard seeds yield is very white, and makes good bread when properly manufactured. It is called *durra* in India, and is said to be used chiefly by the lower classes of the population. It is also employed for feeding horses, swine, poultry, &c., where it is extensively grown. It is frequently cultivated in Botanical Gardens in England, where it has been tried also as a general crop, but the climate has been found too cold and damp for ripening its seeds properly. *S. saccharatum* has lately been recommended as a fodder grass.

Sori (Gr. σωρός, *a heap*). The small heaps of reproductive granules found growing upon the fronds of Polypodiaceous ferns.

Sorites (Gr. σωρείτης, from σωρός, *a heap*). In Logic, an abridged form of stating a series of syllogisms, in which the conclusion of each is a premiss of the succeeding one: e. g. A=B, B=C, C=D; therefore A=D. This is a sorites, consisting of two distinct syllogisms, which, drawn out at length, would stand thus: A=B, B=C; therefore A=C; and A=C, C=D; therefore A=D.

Sorosis (Gr. σώρευσις, *a heaping up*). In Botany, the term applied to those fruits which consist of a fleshy mass formed by a consolidation of many flowers, seed-vessels, and their receptacles, as in the Pineapple, the Bread-fruit, &c.

Sorrel, Salt of. Binoxalate of potash.

Sortes Homericæ, Virgilianæ, Sanctorum, &c. A species of sortilege or divination was practised in antiquity by opening at random a favourite author, and applying the first passage which met the eye to the circumstances of the enquirer as an oracular answer: termed by the Greeks στοιχειομαντεία. They chiefly used Homer for this purpose. Thus

Socrates when in prison, hearing the line of Homer repeated,

ἤματί κεν τριτάτῳ Φθίην ἐρίβωλον ἱκοίμην,

interpreted it to foretell his own death within three days, by a play on the word Phthia. Among the Romans, Virgil was chiefly consulted, and many celebrated instances are preserved. Hadrian, when desirous to know on what terms he stood with his patron, the emperor Trajan, consulting the *Æneid*, opened at the verses respecting Numa, 'Nosco crines incanaque menta Regis Romani,' &c.; and thence drew the augury of his future elevation to the empire. Alexander Severus, according to Lampridius, obtained a similar presage from the lines 'Excudant alii spirantia mollius æra,' &c. The anecdote of the ominous passages discovered by Charles I. and Lord Faulkland, when opening Virgil in the public library at Oxford, is well known. (Welwood's *Memoirs*.) In Christian times, the Sortes Sanctorum came in fashion. They were obtained by consulting the Biblical writings in the manner before described; sometimes, also, the enquirer went into a church while service was performing, and drew a prognostic from the first words he heard. In this way, St. Anthony was directed to adopt a life of solitary devotion. These practices became the occasion of much superstition. They are condemned by St. Augustine in his Epistle to Januarius; but are, nevertheless, continually mentioned, with evident credulity and approbation, by early ecclesiastical writers. Gregory of Tours, among other similar stories, has one of the French prince Meroveus, which shows the ceremonious manner in which they were sometimes performed. That prince having fled to the basilica of St. Martin, placed separately on the saint's tomb the Psalms, the Book of Kings, and the Gospels, and, spending three days and nights at the tomb in fasting and devotions, on the fourth day he opened these sacred books; from each of which he drew a discouraging prediction. Elections to the episcopal offices, and other solemn proceedings, seem to have been sometimes decided in the same manner in the dark ages. And after this abuse had ceased, it was long a common practice, on the consecration of a bishop, after the book of the Gospels had been laid on his head, to consider the first verse which offered itself as a prognostic of his behaviour and the fortunes of his episcopacy. The Sortes Sanctorum had been, however, forbidden by the council of Vannes in the fifth century, and that anathema was repeated on many later occasions, in which this method of consulting the Scriptures is classed with other profane and magical modes of divination. There is an essay on Sortes in the *Mém. de l'Acad. des Inscr.* vol. xix. [STICHOMANCY.]

Sortie (Fr.). In Military language, a sudden attack made by the garrison of a besieged place upon the besiegers.

Sortilege (Lat. sors, *lot*; lego, *I collect*). Divination by lots. The different modes in which sortilege has been practised will be found detailed under that word, in a learned article in the *Ency. Metropolitana*. [MAGIC; SORTES; WITCHCRAFT.]

Sospiro (Ital. *a sigh*). In Music, the same as REST.

Sostenuto (Ital. *sustained*). In Music, a term which, affixed to a note, indicates that it is to be held out in an equal and steady manner.

Sothiac Period. In the artificial Chronology of the Egyptians, a period of 1,461 years, based on the observation that the movable year of 365 days, and the fixed year of 365¼ days could not, after starting from the same point, again coincide, until a cycle of 4 x 365, i.e. of 1,460, years had been completed. This period is also termed Canicular, Sothis being the Egyptian name for the dog star. A passage of an ancient chronicle, cited by Syncellus, speaks of a great cosmical period of 36,525 years, made up of twenty-five Sothiac periods. The later chronology was constructed on the same principle. Theon of Alexandria reckons an era of Menophres as beginning in the year 1322 B.C., which corresponds with the first year of the Canicular period, whose termination is mentioned by Censorinus (1322 + 139 = 1461); and therefore it may be inferred that the era of Menophres was a period of 1,461 years, calculated backwards from A.D. 139, in which the first of Thoth (the first month) in the Egyptian movable year, occupied its proper place at the rising of the dogstar. This period is not mentioned by Herodotus, or by any other writer before the Christian era. (Sir G. C. Lewis, *Astronomy of the Ancients*, ch. v. § 9; Grote's *History of Greece*, part ii. appendix to ch. xx.)

Sothic Year. The Egyptian year of 365 days was so called from Sothis, the dog star, at whose heliacal rising it was supposed to commence. [SOTHIAC PERIOD.]

Sotto (Ital. *below*). In Music, a term frequently used for description; as *sotto il soggetto*, below the subject; *nella parte di sotto*, in a lower part.

Sou (Lat. solidus, sc. nummus, *a solid coin*). A French coin, the twentieth part of a franc.

Souari Wood. A valuable Demerara timber, the wood of *Caryocar tomentosum*.

Soujee. A species of Semolina; it is a granular preparation of wheat deprived of bran.

Soul. This word, which is still used in many senses, is more distinctively employed to denote the spiritual, or immaterial, or immortal, portion of human nature; but even in this sense it has not attained, and is perhaps incapable of receiving, a precise philosophical meaning. Like all other words which have been used to convey purely intellectual ideas, the term *soul* has a strictly sensuous origin. As the words which we now use to signify the spirit of God meant originally only the breath of the air or sky, so the word *soul*, as applied to the thinking faculty in man, is a metaphor derived from the heaving and restless *sea*. 'Soul,' says Professor Max

Müller, 'is the Gothic *saivala*, and this is clearly related to another Gothic word, *saivs*, which means the sea. The sea was called *saivs* from a root *si* or *siv*, the Greek σείω, to shake; it meant the tossed-about water in contradistinction to stagnant or running water. The soul being called *saivala*, we see that it was originally conceived by the Teutonic nations as a sea within, heaving up and down with every breath, and reflecting heaven and earth on the mirror of the deep.' (*Lectures on Language*, first series, ix.) To the objection made to this derivation, on the ground that poetry is thus made to do duty for logic, it is sufficient to reply in the words of Locke, that in all languages the names which stand for things not falling under our senses have had their first rise from sensible ideas. This proposition, as put forth by Locke, was in part a conjecture, grounded on an examination of certain words; but the progress of philology has fully established the fact. [LANGUAGE; METAPHOR.] The metaphorical character of this name for the thinking faculty of man, is further shown by the unconscious instinct with which poets resort to the idea embodied in it. (*Quarterly Review*, April 1866, p. 412.)

In this its original meaning, the word denoted simply a present fact, or the impression conveyed to the speaker by certain phenomena which he was contemplating. It had now no reference either to the source of this faculty or life, or to its ultimate duration, whether here or in any other state of existence. The soul was the heaving sea within man, during the whole of that period in which the words *Dyaus*, Ζεύς, Θεός, *Deus*, signified simply the heaven to which men looked up from the earth. The history of language carries us back to a time during which men existed without any consciousness of kinship, marriage, or law, or of their relation to a Being who was their maker. The first formation of the ideas of father, mother, wife, and brethren, the growth of the numerals, of words like duty, right, love, of the idea of a Creator, Ruler, and Father of men, mark severally, in Professor Max Müller's judgment, a stage in the revelations made to mankind.

How soon these words began to convey ideas similar to those which we now attach to them, it is impossible to say. But it is quite certain that the word *soul* assumed gradually the meaning of a living, thinking, or conscious power, and equally certain also that while some held this power to be indestructible, others either denied this conclusion, or rested content without any conclusions on the subject. In other words, the belief in the inherent immortality of the human soul, although affirmed by some to be an innate conviction in the human mind, has not been accepted at all times or in all countries. From the Buddhist theories of Nirvana it may perhaps be rash to draw any inference [UPADANA]; but in the western world the denial of this doctrine has been formalised in philosophical systems, more especially in the later phases of that of Epicurus. A treatise of Philodemus, *On Death*, found among the Herculanean papyri, attests (if any evidence were needed) a condition of thought in which the mind calmly accepted the grave as the limit of its destiny, and 'acquiesced without an effort in the contented consciousness of annihilation.' It has been further remarked that this is no passing allusion to the sleep of death. 'Philodemus coolly discusses all the circumstances of death, and calmly puts aside all the terrors which they involve, by the single consideration that since man, by the enjoyment of life, has attained the chief good, he is not to concern himself with what may afterwards befal. The children, therefore, whom we may leave behind us, are no more to us than they are to those who were born to King Phoroneus.'

In the Aristotelian philosophy, the idea of a future or continued existence after death can scarcely be said to have a place. His system of ethics is simply a part of his great theory of politics, and his morality is confined, therefore, essentially to present conditions. The passing reference made to the subject in the first book of the *Ethics*, shows a singular indifference to a question on which the philosopher was content to balance one conjecture against another. He will not take upon himself to assert, like Philodemus, that the fortunes of the children can in no way affect their ancestors; but he thinks that the impressions conveyed are like those with which we may regard those incidents in a play which are supposed to be enacted behind the scenes, and which do not therefore pass before our eyes. Thus the continued existence of men after death was with Aristotle an open question, for which he did not greatly care to have an answer.

The Platonic philosophy, or the Socratic (if we may suppose that on this subject the disciple faithfully represented the master), introduces us to a wholly different phase of thought. The idea of duty, as based on responsibility, to an unseen but absolutely impartial judge, runs through the great dialogue entitled the *Gorgias*. The belief, if grounded in part on metaphysical arguments, rests chiefly on a profound internal conviction. After death comes the judgment, and as the tree falls so it lies. As the corpse retains the features seen in life, with any marks or scars which may have been made in the body, so the soul retains its spiritual features, with the wounds or scars which may have been caused by unjust actions. The souls, dismissed from the body, are brought before Rhadamanthus the judge, who knows not to whom they belong, and whose impartiality cannot therefore be called into question; and the souls of kings, rulers, and statesmen, are thus submitted to a trial, at the end of which sentence is passed according to the condition in which they are found. Those which are found unscarred go to the islands of the blessed; while all who are wounded and distorted from the effects of tyranny, intemperance, sloth, or lying, are dismissed to the prison-house where they are to receive due punishment.

The souls so dismissed are divided into two classes, the curable and the incurable, for punishment must be either for the reformation of the offender or as a warning to others. For all, therefore, who have not sinned incurably, the punishments of Hades become a purgatorial process, and in this class are placed the souls of private citizens who have never been invested with great power or responsibility. According to the Platonic Socrates, it is impossible for such insignificant persons to commit incurable sins, this terrible privilege being reserved for despots, unjust kings, and iniquitous rulers of whatever kind. Thus, for the vast mass of men, the punishments of the unseen world issue in reformation and final happiness.

The Platonic belief was adopted by Cicero, who sums up in his treatise, *De Senectute*, the metaphysical arguments on which belief in the immortality of the soul has been based. Not only will the soul exist hereafter, but it has existed before the birth of the body. [REMINISCENCE.] It is a portion of the universal Divine Mind, and its power of remembering the past, its foresight, and its achievements in science and art furnish conclusive evidence that the nature which can do all this is immortal. The mind, again, is never at rest, and its motion, as not being caused from without, originates with itself, and can, therefore, have no end, as the soul cannot abandon itself. It is, again, simple and indivisible, and that which is indivisible is also indestructible. His belief in a conscious personal existence after death Cicero expresses rather incidentally than in positive propositions; but his own convictions may be seen in the words in which Cato is represented as expressing his longing to be again with his own son, and with great and good men whom he had never seen on the earth.

But neither in the time of Cicero, nor at any other period of Roman history, can it be said that there was a general belief in the inherent immortality of the soul. So far as Tacitus can be adduced as having a settled belief, he had come to the conclusion that man, as such, was not immortal, but that immortality might be conferred as a special reward on great souls (*Agricola*, 46), and Tacitus represents probably the better aspect of Roman thought.

The arguments urged by Bishop Butler (*Analogy*, part i. ch. i.) agree generally with those which Cicero derived from the Platonic philosophy, while in some points they extend the field of enquiry, and introduce new considerations which may materially affect the question at issue. Of death in itself we know nothing, but only some of its effects, as the dissolution of flesh, skin, and bones; hence the reason of the theory fails to connect death with the destruction of living agents, and thus there is no presumption that any 'animals ever lose their living powers.' The body is, therefore, defined by Butler to be a living power, which makes use of the limbs as instruments; and as only these instruments are subject to the change called death, it follows that the body (as being a living power) never dies. This conclusion only presents in another form the Platonic argument of the indiscerptibility of the human soul; and thus from Butler's position it follows, apparently, that man is one indivisible living power, and therefore that the distinction between body and soul has no foundation in fact. Butler likewise saw that his argument was capable of application to the life or soul of brute animals, and he did not shrink from so applying it. The raising of a difficulty on this account he regards as both invidious and weak, for we know not with what latent powers and capacities they may be endowed, and, secondly, 'the natural immortality of brutes does not in the least imply that they are endued with any latent capacities of a rational or moral nature; and the economy of the universe might require that there should be living creatures without any capacity of this kind.'

But while it has become a habit with many to appeal to the universal consent of mankind as evidence for the inherent immortality of man, both this appeal and the metaphysical arguments on which this belief is maintained are confronted by a system of philosophy, sometimes called materialistic, which sees in human life the expression of forces dependent on certain material combinations, and which, asserting that consciousness is the result of that combination, affirms that, with the dissolution of that combination, the conscious life will also be at an end. Into the vast field of discussion thus opened it is unnecessary to enter in an article which is designed simply to sketch the chief theories or convictions which have been propounded on the subject. It may, however, be remarked that, in the system of Bishop Butler, the soul seems to be identified with the principle of reflection or conscience, which he holds to be supreme in authority, as it ought to be supreme in power, and that here, again, the subject branches off into many complicated enquiries. According to Butler, the conscience is a substantive innate faculty or power, the voice of God speaking within us; according to the 'Association' psychology, that which we call conscience is the result of experience, varying indefinitely with the civilisation in which man may find himself, and with the particular circumstances of his life. (Bain, *The Senses and the Intellect: The Emotions and the Will.*)

And, finally, it may be noted that, while the idea of inherent immortality is generally maintained by Christian theologians, the consent is by no means universal. There are many who share the belief of Archbishop Whately (*Scripture Revelations of a Future State*) that immortality is a gift reserved only for those who shall be found worthy of it; the eternal death spoken of in the New Testament being the final extinction of the sinner, and not his continued existence in a state of endless torment.

Professor Bain gives the following classifi-

cation of views held by different schools of philosophy on the subject of the Soul.

I. Two Substances.
1. Both material: most of the ancients; the early fathers.
2. An immaterial and a material: commencement in Plato and Aristotle; the later fathers; the schoolmen; Descartes; prevalent opinion.

II. One Substance.
1. Mind and matter the same: the cruder forms of materialism; the pantheistic idealism of Fichte.
2. Contrast of mind and matter saved: guarded or qualified materialism, held by many physiologists and metaphysicians; the growing opinion.

For a sketch of the Hindu philosophy on the subject, the reader is referred to the Introduction to Professor Max Müller's *History of Sanskrit Literature*. See also Alger's *Critical History of the Doctrine of a Future Life, with a complete Bibliography of the Subject*, Philadelphia 1864; Bain, 'Historical View of the Theories of the Soul,' *Fortnightly Review*, No. xxv., May 15, 1866.

Soulamea. A genus of the *Simarubaceæ*, peculiar to the Moluccas and the Feejee Islands. *S. amara*, the only species, is a tree with simple alternate obovate leaves, and small green flowers in short axillary spikes. Like the *Quassia* and most others of the family, this plant is excessively bitter in all its parts. The root and bark, bruised and macerated in water, are used in India, Java, the Moluccas, &c., as emetics and tonics, in pleurisy, asthma, cholera, snake-bites, epilepsy, &c.

Sound (Fr. son, Lat. sonitus). The sensation produced by the vibrations of the air or other medium with which the organ of hearing is in contact. The doctrine of sound is usually treated under the head *acoustics*; a branch of physics which has for its object the determination of the laws by which the peculiar motions which give rise to the sensation of sound are produced in bodies and conveyed to our ears, and the manner in which they act on those organs; in other words, to explain the origin, propagation, and perception of sound.

Although, strictly speaking, sound is only a sensation excited in the auditory organ, yet in treating of the subject it is usual to transfer the name from the sensation to the motion which gives rise to it. We shall therefore speak of sound as if it proceeded from the *sounding* body; and speak of a body as sounding when its particles are in that state of vibration which is requisite for making an impression on the ear, either immediately or through the medium of some other elastic substance.

Transmission of Sound.—In order that a body may produce sound, it is necessary that its particles be in a state of rapid vibration; and in order that these vibrations may be communicated to the auditory organ, it is necessary that air or some elastic medium be interposed between the vibrating body and the ear. Hawksbee having suspended a bell under the receiver of an air-pump, found the sound become feebler in proportion as the air was removed, and again become stronger as the air was readmitted; and also that when the bell was suspended in a vessel full of air, and placed under the receiver, no sound was transmitted when the air between the vessel and the receiver was exhausted. This experiment has been repeated by Biot, with a more perfect apparatus, and with every attention to the circumstances by which it is influenced; and it was found that when the exhaustion was complete no sound was perceptible, even when the ear was brought close to the receiver. Hence it appears that sound cannot be communicated through a perfectly void space. But although air is the medium through which sound is usually communicated, this happens only because it is the medium with which the ear is usually in contact; and many other media are found by experiment to perform the office even more perfectly. Franklin having plunged his head under water, caused a person to strike two stones together beneath the surface, and at more than half a mile distance heard the blows distinctly. Colladon, in 1827, by plunging into the water a spoon-shaped trumpet closed at the lower end, but having the upper—to which the ear was applied—open to the air, was by this means enabled to hear the sound of a bell struck under water at the distance of 12,000 mètres, or about nine miles. The experiment was made across the whole breadth of the lake of Geneva, from Rolle to Thonon. The conducting power of wood along the fibres is very remarkable. Let a person bring his ear close to the end of a fir deal, however long, and he will distinctly hear the slightest scratch made with the point of a pin at the other end, although the sound may be so feeble as to be inaudible to the person who makes it. Miners at work in one shaft often hear the sound of the pickaxe in another through the solid rock; and in general all solids tolerably compact are good conductors of sound.

Sounds are propagated to great distances and with remarkable distinctness over a surface of water, or ice, or frozen snow. In the account of Parry's third polar expedition, it is stated that two persons could hold a conversation across the harbour of Port Bowen, a distance of 6,696 feet, or about a mile and a quarter. Instances are also recorded of sounds propagated to almost incredible distances over land. Derham relates the following: Guns fired at Carlscrona were heard across the southern extremity of Sweden, as far as Denmark, a distance of 120 miles. Dr. Hearn, a Swedish physician, relates that he heard guns fired at Stockholm at the distance of 30 Swedish or 180 English miles. The cannonade of a sea-fight between the English and Dutch, in 1672, was heard across England as far as

Shrewsbury, and even in Wales, a distance of upwards of 200 miles from the scene of action. The firing at Waterloo, it is said, was heard at Dover; and the report of a volcano is said to have been heard 300 miles off.

The diminution of the intensity of sound in rarefied air is rendered manifest not only by experiments with the air-pump, but also by the phenomena observed at great altitudes in the atmosphere. Saussure relates, that at the summit of Mont Blanc the report of a pistol was not louder than that of a small cracker in the plain below; and Gay-Lussac, having ascended in a balloon to an altitude of nearly 23,000 feet, observed the intensity of the sound of his voice to be greatly enfeebled.

Velocity of Sound in Air.—It is a familiar observation that sounds are not propagated through the air instantaneously, but occupy a sensible portion of time in passing from one station to another, greater in proportion as the stations are more remote. The blow of a hammer on an anvil is not heard by an observer at some distance, until a sensible time has elapsed after the hammer has been seen to descend; and the flash of a gun fired a mile off is seen several seconds before the report is heard. But all sounds, whatever be their loudness or pitch, are propagated with the same velocity through the same medium. In listening to the music of a concert, the sounds follow each other in the same order and at the same intervals; and the same measure and harmony are perceived, at whatever distance the hearer may be from the orchestra. Biot caused several airs to be played on a flute at the end of a pipe 3,120 feet long, which were distinctly heard at the other end without the slightest derangement in the order or intervals of sequence of the notes. This could not have been the case if there had been the smallest difference in the velocity of their propagation.

Numerous experiments have been made for the purpose of determining the actual velocity of sound through the atmosphere. The usual mode of making the experiment is to observe the interval between the flash and the report of a cannon fired at a known distance. In this manner the Florentine academicians, in 1660, found the velocity to be 1,148 English feet per second. These experiments were repeated in France in 1698, by Cassini, Huygens, Picard, and Roemer, who found 1,172 feet; and Flamsteed and Halley at the Royal Observatory of Greenwich, from experiments made at the distance of three miles, found the velocity to be 1,142 feet per second. This result was confirmed by Derham (*Phil. Trans.* 1708), who found the same velocity by a mean of observations made at more remote distances. In 1737, the Academy of Sciences of Paris directed further experiments to be made by Cassini de Thury, Maraldi, and Lacaille; and on this occasion the experiments were for the first time made so as to eliminate the effect of the wind by reciprocal observations, i.e. by firing cannon at both ends of the line, either simultaneously or at short intervals. They also appear to have been the first who observed and recorded the temperature of the air at the time of the experiment—a very essential element, as will presently be seen. The result at which they arrived gave the velocity equal to 1,106 English feet per second, at a temperature between 4° and 6° of Réaumur, or between 41° and 44½° of Fahrenheit. When the proper reduction is made for temperature, this agrees very nearly with the best modern observations.

Since the beginning of the present century, the velocity of sound has been measured by numerous observers with great care. The following table contains a summary of these and other results:—

Date of Observation	Observer	Distance of Stations in Feet	Velocity per Second in English Feet at the Temperature of Freezing Water
1809	Benzenberg . .	29764	1095
1821	Goldingham .	29547 13932	1086·7
1822	Myrbach . . .	32615	1092·1
1822	Arago, Mathieu, &c.	61064	1086·1
1823	Moll and Vanbeck .	57839	1089·42
1823	Dr. Gregory .	from 2700 to 13460	1088·05
		Mean of the whole	1089·2

These results agree remarkably well with each other, the greatest deviation from the mean being less than four feet, and the mean of the whole being almost identical with the determination of Moll and Vanbeck. 'We may, therefore,' says Sir John Herschel, 'adopt 1,090 feet without hesitation (as a whole number), as no doubt within a yard of the truth, and probably within a foot.' This is the velocity with which sound travels in dry air, at the temperature of freezing water. But the velocity increases with the temperature (as will be shown presently) at the rate of 1·14 foot, very nearly, for each degree of Fahrenheit's scale. Hence at the average temperature, say 60°, the velocity of sound is about 1,120 *feet per second.*

Theoretical Determination of the Velocity of Sound.—The investigation of the velocity of sound through the atmosphere (or any gaseous medium) is based upon this fundamental proposition of dynamics, viz. that the velocity of the pulses in an elastic medium is as the square root of the elasticity divided by the density of the medium. Let v = the velocity, e = the elasticity, d = the density; and the proposition gives $v = \sqrt{(e \div d)}$. Make g = the measure of gravity (386·29 inches per second), w = weight of the unit of volume of air, h = height of the homogeneous atmosphere (i.e. of a column of air of the same density throughout, and whose weight exercises on the base a pressure = e); we have then $e = hwd$, $= w \div g$; and the above equation becomes $v = \sqrt{(gh)}$. But this is the velocity which a heavy body acquires by falling in vacuo from a height $= \frac{1}{2}h$; therefore, the velocity with which sound is propagated through the air is the same as

that which a heavy body would acquire by falling through half the height of the homogeneous atmosphere. This proposition was given by Newton in the *Principia* (lib. ii. prop. 47), but from a theory wholly inapplicable. The correct demonstration was given by Lagrange.

In order to convert this formula into numbers, it is necessary to determine h. Let b = the standard height of mercury in the barometer, and m = the ratio of the density of mercury to the density of atmospheric air under the same pressure; then $h=mb$, and the velocity becomes $v=\surd(gmb)$. At the temperature of freezing water (32° Fahr.), and under a barometric pressure of 29·927 inches, the value of m is found by experiment to be 10.466. But we have also $g=386{\cdot}29$ inches; whence at that temperature $v=10{,}998$ inches, or 916 feet.

Since the velocity, as above stated, is proportional to the square root of the elasticity divided by the density, an alteration in the height of the barometer, while the temperature remains the same, will produce no change in the velocity; for an increase of pressure, and consequently of elasticity, is accompanied by a proportional increase of density. An increase of temperature, however, by increasing the elasticity without changing the density, is accompanied by an augmentation of velocity. The correction for a difference of temperature is found as follows: Let t denote the number of degrees of temperature on Fahrenheit's scale above 32°, and a a constant coefficient; then the elasticity at the freezing temperature being e, the elasticity at the temperature t will be $e(1+at)$. But the value of a is found by experiment $=\cdot00208$; therefore the elasticity is $e(1+\cdot00208\,t)$; and the formula for the velocity becomes $v=\sqrt{gmb\,(1+\cdot00208\,t)}$; or introducing the above value of $g\,m\,b$, $v=916\,(1+\cdot00104\,t)$.

The velocity of 916 feet at the freezing temperature, thus deduced from theory, falls short of the experimental velocity (which has been shown above to be 1,089 feet) by 173 feet, or about a sixth part of the whole quantity. This discrepancy was remarked by Newton, who attempted to account for it by supposing the spherical molecules of air to be perfectly elastic solids, through which sound is propagated instantaneously; but the true solution of the difficulty was reserved for Laplace. The explanation given by Laplace is, that the compression of the air which takes place in the vibration disengages a portion of latent heat, which thus becomes sensible, and modifies the law of the elasticity, thus accelerating the velocity. On submitting this to calculation, he found that the formula for the velocity of sound must be multiplied by a certain factor, viz. the square root of the quotient which is found by dividing the number which expresses the specific heat of the air (or other gas) under a constant pressure by that which expresses its specific heat under a constant volume. Let k = this factor; then Laplace's formula for the velocity of sound is

$$v=\sqrt{gmb\,(1+\cdot00208\,t)\,k}.$$

The value of k for atmospheric air, as determined by Dulong, is 1·421; hence $\surd k=1{\cdot}192$, and the formula in numbers is

$$v=916\times1{\cdot}192\,(1+\cdot00104\,t)=1092+1{\cdot}14\,t,$$

which is almost identical with the experimental determination.

Velocity of Sounds through Liquids and Solids.—The following general formula for the velocity with which sound is propagated through any elastic compressible body, whether liquid or solid, was found by Laplace: Let b denote (as before) the standard height of the barometer, D the density of mercury at the freezing temperature, d the density of the medium, and c the *compressibility* of the medium, i.e. the diminution of bulk caused by an additional pressure equal to one atmosphere; then the formula is

$$v=\sqrt{\frac{gb\,D}{c\,d}};$$

or (since $g=386{\cdot}29$ inches, $b=29{\cdot}927$ inches, $D=13{\cdot}568$), $v=396{\cdot}04\ \surd(1+cd)$ inches, or $33\ \surd(1\div cd)$ feet per second. Applying this to the case of water, we have $c=\cdot000049589$ (Herschel, *Ency. Metrop.*), and $d=1$; whence $v=4{,}687$ feet per second. This result agrees very nearly with the velocity determined by Colladon and Sturm by direct experiment on the propagation of sound through the lake of Geneva, the velocity actually observed by them being 1,435 mètres, or 4,708 English feet, a second, which differs from the theoretical velocity only by 21 feet—a space described by the aqueous pulse in the 200th part of a second.

By the above formula the velocity of sound through any medium of which the compressibility is known is readily computed. According to Chladni, the velocities of sounds in different solids, that of air being taken as unity, are as follow: Tin = 7½, silver = 9, copper = 12, iron = 17, glass = 17, baked clay = 10–12, woods of different kinds = 11–17. But the velocity of propagation through cast-iron tubes was determined experimentally by Biot, and found to be only about 10½ times its velocity in air. (Herschel's *Treatise on Sound*; Chladni, *Traité d'Acoustique*; Biot, *Traité de Physique*.)

It has already been stated that sound is produced by the vibrations of the molecules of any substance communicated to the atmosphere or other elastic medium, and conveyed by it to the ear. The physical theory of sound, therefore, is resolved into two parts: 1st, the state or condition of the vibrating body; and 2nd, the mode in which this mechanical action is propagated through the medium to the organ of sense.

State of Sonorous Body.—In order that a body may emit a musical sound, its particles must be put into a state of rapid and regular vibration. If the frequency of the vibrations is under a certain limit, no sound will be pro-

duced; above that limiting velocity of vibration, sound is produced; and experience shows that the pitch of the sound becomes more and more acute as the vibrations are more rapid, until a second limit of velocity is attained, beyond which the human ear is affected with no sensation of sound. To prove this experimentally, let a strip of tempered steel have one of its ends firmly fixed in a vice, and let the other end be drawn aside from the position of rest. As soon as the force by which the strip is bent is removed, the steel commences a series of vibrations, which become smaller and smaller until the position of rest is again attained. But the vibrations are all performed in equal times, and if sufficient length is given to the strip, they take place so slowly as to admit of being accurately counted. On shortening the strip, they become more rapid; and at a certain length a low sound is emitted. If the strip be still further shortened, a fiddle-bow drawn over its upper edge will be necessary to throw it into vibration, and a higher note will now be heard. By continuing to reduce the length of the strip, the pitch of the note will correspondingly rise; for the excursion of the steel to and fro is augmented in rapidity, and the *pitch* of a note depends on the rate of vibration. It might perhaps be possible so far to shorten the strip, and still to throw it into vibration, that its last shrill note shall be followed by no audible sound.

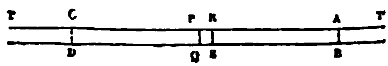
Long before the vibrations of the strip attain that degree of rapidity which is necessary for the production of sound, it becomes impossible to count them directly. But it is demonstrable that when a strip of metal of equal thickness throughout is made to vibrate in the manner now supposed, the time of a vibration is directly proportional to the square of the length of the strip, and consequently the number of vibrations in a given time is inversely as this square; so that if the number in a second corresponding to any length of the strip has been counted, the number corresponding to any other given length can be readily computed. In this manner it has been found that a metallic strip or plate begins to sound when the number of complete vibrations in a second is 16; and at this velocity of vibration, the sound which it gives is of the same pitch as that of an organ pipe 32 feet in length, open at both ends.

This appears to be the minimum velocity of vibration capable of producing sound. The other limit, or maximum velocity at which sound ceases to be appreciable, has also been determined. Until recently it has been usual to fix it at 8,200 vibrations in a second; but Savart has discovered that by increasing the amplitude of the vibrations, acute sounds may be distinguished at a velocity of 24,000 whole vibrations in a second; and more recently Despretz has fixed the upper limit of audible sounds at 36,800 whole vibrations per second. The number of vibrations producing a sound of any given pitch can be determined with great ease and exactness in various ways. Savart employed for this purpose a cog wheel which was made to revolve, and in doing so the teeth were caused to strike a piece of card. A musical sound of any pitch could thus be produced by regulating the velocity of the wheel. The number of revolutions being indicated by machinery, the number of vibrations made by the card could be at once found by multiplying the revolutions of the wheel by the number of teeth it contained. Still more perfectly may the rate of vibration be determined by means of an ingenious instrument, invented by Cagniard Latour, called the *syren*. [SYREN.]

Some of the most acute sounds, or highest tones which the ear can distinguish, are given by the wings of insects; and they correspond to the astonishing rapidity of 12,000 or 15,000 vibrations in a second. When we reflect how extremely probable it is that the tympanum of the ear vibrates in unison with the sounds that affect it, we cannot fail to be struck with the wonderfully delicate organisation of a substance which possesses the power of adapting itself to all velocities of vibration, from 16 times in a second up to 30,000, or even higher. The limits, however, at which very acute sounds cease to be audible appear to vary considerably in different individuals, some being altogether insensible to sounds which painfully affect others. For example, the piercing chirp of the grasshopper is quite unheard by some persons. (See a very interesting paper on sounds inaudible to certain ears by Dr. Wollaston in the *Phil. Trans.* for 1820.)

Propagation of Sound.—In order to convey an idea of the manner in which the vibratory motions of a sonorous body are communicated to the atmosphere or other elastic medium, let us conceive a tube, T T′, of an indefinite length,

Fig. 1.

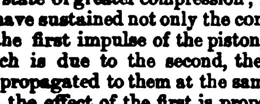


and open at both ends, to be filled with air of a uniform temperature and density throughout. Let us also suppose a piston, P Q, which closely fits the tube, and is movable within it along the direction of the axis, to be propelled suddenly from the position P Q to R S; and to simplify the consideration, let the distance P R be supposed one foot, and the time in which the piston moves from P Q to R S to be one second. Now, assuming the air within the tube to have been in a state of rest before the piston began to move, let us consider what will be its state at the instant when the piston arrives at R S. If the air in the tube were acted upon as a perfectly hard body, any motion communicated to the particles at one extremity would be instantaneously conveyed to the other; and when the piston arrived at R S a quantity of air, equal to that which was contained between P Q and R S, would be expelled at T′, and all the particles within the tube would come to rest at the same time with the piston. But in

consequence of the compressibility of the air the motion is not communicated to the distant particles instantaneously, but only after a sensible interval of time; and we may conceive the tube to be so long that when the piston has arrived at R S no air has yet been propelled from the tube at T'. In fact, the disturbance or compression of the particles, which takes place at the instant the piston begins to move, is propagated along the tube with a certain determinate velocity, depending on the elasticity of the air, and when the piston reaches R S will only have reached to a certain determinate distance. Let A B be the section of the tube which the first compression has reached at the instant the piston comes to R S; then, at the instant of time on which we have to fix our attention, the column of air between R S and A B will be in a state of compression, and betwen A B and the end of the tube at T' it will still remain in its natural state. The column of air between R S and A B, which is thus modified by the stroke of the piston, is called a *condensed wave*.

On attending to the state of the molecules in the column R A, it will readily be seen that they are not subjected to the same degree of compression through its whole length. Conceive the wave to be divided into a very great number of thin layers by sections parallel to R S or A B, and that the piston, in passing from the position P Q to R S, has produced the effect, not instantaneously, but by a great number of successive small impulses. At the instant the piston comes to R S the disturbance has by hypothesis been propagated only to A B, and consequently the particles in the infinitely thin layer next to A B have suffered only the slightest degree of compression, or that caused by the first impulse of the piston. In the second layer next to A B the molecules of air are in a state of greater compression; inasmuch as they have sustained not only the compression due to the first impulse of the piston, but also that which is due to the second, the effect of which is propagated to them at the same instant at which the effect of the first is propagated to A B. In like manner, the compression in the third layer preceding A B is greater than in the second; and so on to the middle of the wave. If we now attend to the state of the molecules at the other extremity R S of the wave, a similar effect will be manifest. The instant after the piston stops, the layer next to

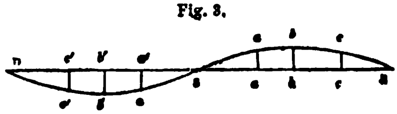
Fig. 2.



R S has communicated all its velocity to the one preceding it, and remains at rest; or, at the moment of the arrival of the piston at R S, sustains only the compression due to the last impulse. The next layer in succession sustains the compression due to two impulses of the piston—the last, and last but one. By following out this mode of reasoning it will readily appear that the particles in the state of greatest compression are those towards the middle of the wave; and that if upon S B, as an axis (fig. 2), we raise a great number of perpendiculars, *a a*, *b b*, *c c*, &c., each proportional to the compression at the corresponding point of the column, the curve drawn through the summits of these perpendiculars will represent the law of compression, and hence is of the form represented in the annexed diagram, the parts on each side of the middle ordinate *b b* being perfectly symmetrical.

If we now attend to the motions developed on the other side of the piston, it will be easily seen that similar phenomena must take place; but in a reverse order, inasmuch as the air within the tube on that side must be rarefied instead of being compressed by the motion of the piston from P Q to R S. Let C D (fig. 1) be a section of the tube, so that the column C R is equal to R A; then, as the velocity of propagation depends only on the nature of the medium, it is obvious that at the instant in which the piston arrives at R S the disturbance of the molecules will have extended only to C D. The whole column between C D and R S will be rarefied by the withdrawal of the piston of air between P Q and R S; but the rarefaction will be greatest at the middle of the column, for the

Fig. 3.



very same reasons which render the condensation greatest at the middle of the column between R S and A B. Hence the column of air between R S and C D is called a *rarefied wave*.

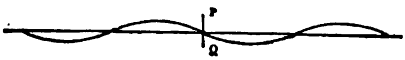
If, now, as in fig. 3, we represent the rarefaction by *negative* ordinates, *a' a'*, *b' b'*, *c' c'*, and the condensation, as before, by the *positive* ordinates *a a*, *b b*, *c c*, the state of the column of air between A B and C D (fig. 1)—and this is all which is modified by the passage of the piston from P Q to R S—will be represented by the double curve D *b'* S *b* B (fig. 3), the small part between P Q and R S being neglected as insensible. The first part of this curve, from D to S, constitutes a rarefied wave; and the second part, from S to B, a condensed wave. Now, as both the rarefied and condensed waves have been produced simultaneously by one motion of the piston, the whole curve from D to B constitutes a single wave or *undulation*. *The length of a wave* is, therefore, the distance between the points D and B, or the distance between the centre of one condensation or rarefaction to the centre of the next.

As every thin stratum of air in the tube, by reason of its elasticity, communicates to the stratum before it the impulse which it has received from the one behind it, all the particles will successively be affected in the same manner; and at the end of a second interval,

equal to that in which the piston has passed from P to Q, the motion will be communicated over another space equal to R A, or the wave will have moved forward its whole length, retaining always the same form; and, supposing the piston to have in this second interval remained at rest at R S, all the particles in the space R A will have returned to their original state of quiescence.

If, instead of supposing the piston to remain at rest at R S, we suppose it to be drawn back, in the second interval of time, to its original position at P Q, then all the phenomena now described will be repeated in the reverse order; i.e. the compressed wave will be to the left of the piston, and the rarefied wave to the right; and the state of the particles within the tube, with respect to their compression, as modified by the advance and subsequent retreat of the piston (a complete *vibration*), will be represented as under (fig. 4).

Fig. 4.



We have now only to suppose this forward and backward motion of the piston to be performed with the same rapidity as the vibrations of an elastic plate or stretched cord, and the phenomena now described will give an idea of the mode in which sound is transmitted through the atmosphere.

From this illustration (imperfect as it is) of the nature of the motions communicated to the air by the vibrating body, it is easy to see that the particles of air in the tube do not change their places inter se, but acquire a vibratory motion, backwards and forwards, along the length of the tube. It is also obvious that the vibrations of the air through which sound is transmitted must be precisely equal in number to those of the sounding body; and as soon as the vibrations cease, those of the air cease likewise. But so long as the body vibrates, or the reciprocal motion of the piston is continued with the same velocity, a continued musical sound will be heard; and this will be precisely the same at whatever part of the tube the ear is situated, all the waves being perfectly similar.

If the production and propagation of a sonorous pulse through a tube has been made clear, it will not be difficult to understand the transmission of sound through an unbounded space of air. Air being equally elastic in all directions, the origin of a sound is a centre from which sonorous waves are propagated in *every* direction. A sounding body thus produces a spherical wave, which rapidly recedes from its source, and, expanding as it does so, its intensity must diminish as the square of its distance from the source increases. As the motion of the sounding body continues, the alternate condensations and rarefactions of the air give rise to a series of concentric spherical waves; a notion of which in section can be derived from rapidly dropping water on one spot on the surface of a quiet lake: the vibrations are here, however, transversal.

Sounds differ from one another in three respects—pitch, intensity, and quality. The *pitch*, or height of the note, depends on the length of the wave, or (which comes to the same thing) on the number of vibrations in a given time. The length of a sonorous wave can therefore be found by dividing the space passed over by sound in one second, in other words the velocity of sound, by the number of vibrations executed in that time; the quotient is the length of the wave produced by that particular note. The gravest tone which the ear can distinguish corresponds to a wave of about seventy feet in length, and the most acute to one of about half an inch. The *intensity* or loudness does not depend on the length of the wave, but on the degree of compression which the air receives; i.e. on the violence of the impulses, or the length of the stroke of the piston in the above illustration. This more forcible stroke causes the particles of air to vibrate through wider spaces; increasing, that is, the height of the ordinates in fig. 3. Hence the intensity of a sound depends on the *amplitude* of the vibration, and is proportional to the square of that amplitude. The *quality* of sound (the *timbre* of the French authors) is less readily explained. It depends in part on the greater or less abruptness of the impulses, and gives rise to the variety in the sounds emitted from different musical instruments. A fuller explanation will be found under the word TIMBRE.

Like light, sonorous waves can be reflected and brought to a focus by a concave mirror; striking on a smooth plane surface, they are reflected to the source, and when this is sufficiently distant the reflected sound gives rise to an *echo*. Sound can also be refracted, and the waves converged to a focus by a suitable lens.

SOUND. In Geography, a strait or inlet of the sea. The name is specially applied to the strait which connects the German Sea with the Baltic.

Sounding. The process of discovering the depth of water beneath a given point, ordinarily on a ship or boat. It may be resorted to merely for a permanent survey, or more commonly for the guidance of the navigator in passing through dangerous seas. The instrument used is a long lead at the end of a light line. In comparatively shallow water the *hand-lead line* is used; its length not exceeding thirty fathoms. In greater depths, resort is had to the *deep-sea line*, which is of unlimited length. The depth is marked by knots on the lines. It is of course important that the plunge of the lead should be as vertical as possible.

Sounding Lead. [LEAD FOR SOUNDING.]

South (A.-Sax. suth, Ger. süd). One of the four cardinal points of the compass; the direction in which the sun always appears at noon to the inhabitants of the northern hemisphere without the tropic.

South Sea Company. In 1711, the proprietors of certain government debts were formed into a joint-stock company, which, in consideration of certain exclusive privileges of trading to the South Seas, offered the government easier terms for the advance or negotiation of loans than could be obtained from the general public. The charter dated from the first of August. The financial expedient of a system by which public debts should be farmed by a company was frequent and to some extent advantageous, and the doctrine that parliament could or should give monopolies of foreign trade was generally accepted. In the present case, it seems that the scheme was intended to rival that of the bank of England. It was favoured by Harley and the Tories, and it was stipulated in the charter that no person should be at once a director of this company and that of the Bank or the East India Company. It was provided that even if the public debt were redeemed, the monopoly of trade should be perpetual. At the time when the company was formed, its stock stood at 77½ per cent., East India being 124½, Bank 111½; and for some time the price of the stock did not rise materially; nor did the company regularly enter on its trading schemes till 1717, when its first annual ship was sent to Vera Cruz.

The origin of the famous bubble of 1720 was the proposal on the part of the directors of the South Sea Company to negotiate all the public debts, at certain rates, and the rivalry which this excited on the part of the bank of England. So keen was this rivalry, that the general public anticipated enormous advantages from the plan, and the stock rose rapidly. It was 126 in Dec. 1719, and reached 319 in the spring of 1720. By the 1st of May it was 400; by June 2, 890. On June 3, it ranged between 640 and 770. On the 6th it was 820, on the 14th 710. By Midsummer it reached 1,000, and other stocks, as that of the East India Company and the bank of England, were similarly exalted. It was said that the advanced prices of all three stocks were computed at 500 millions sterling, and that this sum represented five times all the cash in Europe, and double the value of the lands and houses in England. In order to keep up the price of the security, the South Sea Company, now high in favour with the government, procured a scire facias against the numerous schemes then afloat.

The infatuation, however, was universal. The newspapers were crowded with advertisements of new companies, subscriptions were eagerly paid, and the projectors decamped with the spoils. 'So great was the wild confusion in 'Change Alley, that the same project or bubble was known to be sold at the same instant of time ten per cent. higher at one end of the alley than it was at the other.' One projector actually advertised for a subscription of two millions on a certain promising and profitable design, which would hereafter be promulgated. Pieces of playing-card, called *globe permits*, because they had the impression of a globe in wax, which purported to be a security that the possessor would hereafter be entitled to subscribe into a new sail-cloth manufactory, were sold for sixty and seventy guineas. A list of bubbles is given in Macpherson's *History of Commerce*, some of them being hardly less absurd than the satirical suggestion of a company, with a subscription of two millions, for the invention of melting down sawdust and chips, and casting them into clean deal boards without cracks or knots.

The South Sea Company discovered its error in suing out a suit of scire facias against some of these bubbles, and foresaw that, unless they adopted some expedient, their own ruin was involved in that of their competitors. To defer it, they issued a notice on August 30 that the half-year's dividend should be at the rate of 60 per cent. and that for the next twelve years it should be 50. But these magnificent promises were discredited. The stock sank from 810 on the 1st of September to 410 on the 20th, and to 130 by the last day of the month.

The fraudulent directors of the company, among whom was Mr. Aislabie, the chancellor of the exchequer, were prosecuted and fined, and some small assistance was given out of their estates to a few persons who had been swindled by these officials. But of course a vast mass of misery and ruin remained pitied but unassisted, and long afterwards the most prominent among the great speculations of the year 1720 was known as *the Bubble*.

For thirty years afterwards the South Sea Company continued their trade, though with very imperfect success, and up to almost the present time the capital subscribed to government, which was the plea of their exclusive privileges, was treated as a separate debt, under the name of South Sea Stock.

Southcottians. In Religious History, the followers of Joanna Southcott, who was born at Gittisham, in Devonshire, in 1750, and seems to have first persuaded herself of her miraculous calling in 1792. From that time she traversed the west of England, preaching and prophesying, with a select body of followers, and gradually collected about her a considerable number of disciples. She came to London about 1803, when she announced a meeting for the purpose of satisfying the world of the reality of her mission. Several such meetings took place, the last in 1804; and many persons, including several clergymen, attested their belief in her pretensions. At last, in 1814, she announced her supernatural pregnancy; and this strange announcement took great hold on the public imagination, Dr. Reeve and other medical men having declared their belief that she was actually pregnant in her sixty-fifth year. Her death, in December of that year, did not undeceive her disciples: even when her body was opened, and no trace discovered to verify her assertions, many of them continued to proclaim their

belief in her future reappearance. Her sect continued to exist for many years, nor is it yet altogether extinct.

Southernwood (said to be corrupted from Suddenwood, which name arose from the rapidity with which slips of this plant become suffruticose). A fragrant cottage-garden shrub, the *Artemisia Abrotanum* of botanists.

Sovereign (Fr. souverain; Ital. sovrano; Lat. supernus, *on high*). In Politics, a person, or body of persons, in whom the legislative authority rests in every state. A sovereign state is one in which the jurisdiction of that person or body, within the limits of the state, is absolute and uncontrolled by any foreign authority. The states which composed the German empire were termed, in the language of politics, *mi-souveraines*, because their sovereignty was qualified by their subordination, in some respects, to the imperial authority. The same term should seem applicable to the several states in the American Union, which are commonly, but improperly, termed sovereign; as, on some definite subjects, the power of their legislative bodies is subordinate to that of congress, or the sovereign body in the federal government. [STATE RIGHTS.]

SOVEREIGN. An English coin of the value of twenty shillings, the standard weight of which is 5 pennyweights and 3·27 grains, or 123·374 troy grains. [NUMISMATICS.]

Sow. A movable shed, intended to protect the miners or party using the battering ram in a siege of the middle ages. It corresponds to the ancient *vinea*.

Sow. [SUS.]

Sowans or **Sowins.** The husk and some adhering starch separated from oats in the manufacture of oatmeal are sold, says Dr. Christison, under the inconsistent name of *seeds*; these, if infused in hot water and allowed to become sourish, yield, on expression, a mucilaginous liquid, which, on being sufficiently concentrated, forms a firm jelly, known by the name of Sowins. A similar preparation from groats or oatmeal is called *flummery*.

Sowbread. The common name for *Cyclamen europæum*.

Sowing. In Agriculture and Horticulture, the process of depositing seed in the soil for the purpose of producing plants. The operation of sowing is generally performed in spring, in order that the plants may have the advantage of the coming summer. The seed is either scattered abroad, or deposited in rows or drills; on a small scale by the hand, and on a large scale by a sowing machine. Some seeds which are of large size are planted singly. The covering of seeds is greater or less, according to their size and the texture of the soil. Where the soil is somewhat firm, and the seed is pressed into it by a roller, or by other means, and where the climate is moist, very little covering is necessary; but where the soil is loose, and the climate dry and warm, the covering should be twice or thrice the thickness of the seeds. As the seeds of plants are the natural food of birds, insects, and vermin, in a state of culture artificial protection is required from their natural enemies.

Sowing Machine. A machine for depositing seeds in the soil, either by scattering broadcast, or by dibbling individually, or by placing them in rows, at a greater or less distance asunder. Machines for sowing seeds in rows are termed *drills*. [DRILLS.]

Soy (Japanese sooja). A sauce originally prepared in the East, and said to be produced from the beans of *Soja hispida*.

Soymida (its name among the Telingas). The Rohuna of Hindustan, *S. febrifuga*, is the sole representative of a genus of *Cedrelaceæ*, peculiar to the East Indies. On the Coromandel coast it is known as the Redwood-tree. It is, in fact, a kind of mahogany, and its dull red hard heavy wood is very durable. The bark is a useful tonic in intermittent fevers; but in too large doses it is apt to derange the nervous system, occasioning vertigo and subsequent stupor. It has also been employed successfully in India in bad cases of gangrene, and in Great Britain in typhus fever, and as an astringent. It is a tall tree, with a very bitter astringent bark.

Spa. A place celebrated for its mineral waters, about seven leagues from Aix-la-Chapelle. The term is now generally applied to places at which there are mineral springs.

Space (Lat. spatium). This word signifies generally extension in all directions. Sometimes it has a less general signification; for we speak of distances and areas as spaces of one and two dimensions.

SPACE. In Geometry. Space is not the mere notion of room in which a material object does or may exist, but it is the room in which an object, actual or imaginary, determinate necessarily as to its *form* and possibly as to its *magnitude* and its *position*, does exist. *Form* is the position of all the points of an object as determined by the angular distances between each of them and all the others, and necessitates that a point in or without the object be given. *Magnitude* is determined by the linear distances between any one point in an object, and all other points in it, and requires as given a certain fixed length—a unit of measurement. The form of an object being determined, if the distance between any two points in it be given, the magnitude is determined. *Position* is determined by the linear and angular distances of all the points in an object from at least two points in another object whose position is given. If the form and magnitude of the first object be already determined, the linear distances between any two points in it and any two points in the second object will determine the position of the former, provided that these four points be not all in the same plane. The most generally convenient and common method of determining the form and position of an object is to assume three infinite planes, supposed to be fixed in physical space, at right angles to

each other. These planes will intersect in three lines perpendicular to each other, called the *axes of co-ordinates*. These have a point of common intersection, called *the origin of co-ordinates*, or more commonly *the origin*. Three planes parallel to these planes passing through any point in the object, whose form, &c., are to be determined, will cut the axes in three points, and thus by the portions of the axes cut off between these points and the origin determine the position of that point of the object. These portions of the axes are called the ordinates of that point. If the complete set of the ordinates of all the points of the object be given, its form and position are determined. In certain cases, these can be all given in one or two algebraical formulas which are called the equations to the object. Whenever a unit of distance is given, explicitly or implicitly, in connection with the ordinates of the various points of an object, then not only its form and position, but also its magnitude, is determined. The angular measurement between any two points of an object whose form and position are required is implicitly involved in the system of rectangular co-ordinates, and may be found explicitly from the relations of the sets of ordinates by which these points are determined. It is the assumed perpendicularity of the co-ordinate planes which gives the necessary data for this. These planes need not be assumed to be perpendicular to each other, but then the angles which they make with one another must be known. All material objects possess length, breadth, and thickness, or extension in three dimensions; and if purely geometrical objects, all solids, curved surfaces, and curves of double curvature, must be determined similarly according to their extension in three directions, or they are, as it is commonly expressed, of three dimensions; but certain geometrical figures—viz. plane surfaces, plane curves, and straight lines—have the first only two dimensions, and the two latter properly speaking only one, though the form of plane curves cannot be determined without two dimensions, which are similarly requisite to determine the *position* of straight lines. We therefore assume, as we have said, three co-ordinate planes for the determination of material objects, &c.; but one plane and two lines in it, at right angles to each other, representing the intersections of the two other planes, are all that is necessary for plane surfaces, curves, and straight lines. For purely geometrical objects whose position in physical space we do not require to determine, the co-ordinate planes are not assumed as having any fixed position in that space. [COORDINATES.]

SPACE. In Music, the void between the lines in a musical staff. The spaces are four in number, and the lines five.

Space, Number, and Time. In Metaphysics. Matter as known to us, i. e. as it exists in so far as we are concerned, has always parts. We only know it either as a number of objects, forming parts of a great existing whole —the material universe—or as an object, one of these parts, itself the aggregate of a number of parts. As a whole, also, it is always known to us in a continual variation of state, in a constant change of condition and relation among its constituent parts. Our knowledge of it thus involves three distinct notions—*space*, *number*, and *time*. In their most elementary forms: *space* is the room in which more than one material object, or more than one part of a material object, exist, or, in other words, the room in which matter necessarily (i. e. only known to us as) extended does exist; *number* is the plurality or more-than-oneness of two or more material objects or two or more parts of a material object; *time* is the consecution or non-simultaneity of two states —conditions or relations of a material object. These are not *definitions* of space, number, and time; they add no clearness to our ideas of them; they are only verbal limitations of them to their elementary and primary forms as notions in the human mind. As such notions they are intuitive and cannot be defined, for that what is intuitive cannot be defined is a maxim in logic. Similarly in spiritual existence, as known to us, an intelligence can exist only as an aggregate of consecutive states, and this knowledge, apart from any knowledge of matter, involves the notions of number and time. Space, number, and time, then, are not existences per se; apart from material and spiritual existence we can form no notion of them. To us *extension* is a necessary quality of matter, and it underlies every notion of space, even in its primary form, while those secondary notions of it which we have, as a boundless void, as the distance between two material objects, &c., are, properly speaking, not notions of space, but of real or possible extension. Similar remarks apply to our secondary notions of number and time, which are respectively endless modifications of degrees of plurality, and of the number of changes of state or consecutions in any existence, the sum of which constitutes the duration of that existence. But whilst we cannot conceive the existence of space, number, or time, apart from the existence of matter or spirit, it is equally impossible for us to conceive the latter without the former; the two are indissolubly yoked together—though distinguishable, they are inseparable—we shall, therefore, call space a *conjugate* of material existence, and number and time *conjugates* of all existence both material and spiritual.

The question now naturally arises, Are the notions of space, number, and time, derived from our knowledge of existence, the results of our experience, or, far from being derived from that knowledge, are they not à priori necessary to its existence—elements of that knowledge supplied by the mind in which they are innate? The former is the doctrine of the empirical, the latter of the transcendental school, in behalf of which it has been maintained that, although we cannot prove directly that

these notions are innate, it is, on the other hand, absolutely impossible to prove that they are derived from experience without assuming in the proof the fact of their existence, the very proposition that we propose to prove—or without, as it is commonly called, begging the question. The error of the empiricists, it is urged, has arisen from their not attending to the difference between the elementary and primary notions of space, number, and time, which, and which alone, can be assumed to be innate, and the matured, complicated, and secondary notions – the elaborations of the primary by innumerable inductions and deductions—which we all have long before we are able to reason philosophically on the subject. One form of this error is the employment of the word *space* in its popular meaning of possible extension. Space not being an existence per se, but only a conjugate of material existence, cannot be said to be either finite or infinite, to have length or breadth, or depth, and for such a phrase as *infinite space* to be strictly and metaphysically correct, we should say 'the possibility of infinite extension,' or 'the possibility of infinite material existence.' But while this distinction should always be borne in mind in reasoning as to the notion of space being innate or empirical, it would be inconvenient and unnecessary to introduce such nicety into our arguments on what is generally called the infinity of space, and other similar subjects; while, in the cases of number and time, from the want of other terms to express their various meanings, we must simply be content with laying, and careful to lay, down their limitations when ambiguity would be likely to lead to error.

Sir W. Hamilton and his school, founding on Locke and Kant, have denied the possibility of our forming positive notions of the infinitudes of space, number, and time; but the incorrectness of this doctrine has been demonstrated by several recent authors, and the reader is referred to Mr. J. S. Mill's *Examination of Sir W. Hamilton's Philosophy* for a refutation of it.

Space, Physical. Physical space is the room in which the material universe (the cosmos) exists, or the measure of its extension. The question, therefore, of the existence of infinite physical space, is in reality that of the infinite extension of material existence, and cannot be solved directly, but only by analogy. The question whether, if the cosmos have only finite extension, space be still infinite, is not a physical but a metaphysical question; space meaning in this case not the measure of actual material extension, but the possibility of that extension. That portion of material extension with which we are immediately connected is, we have *learned* to know, continuous; i.e. there is no part of its containing space devoid of matter; the atmosphere which envelopes the earth and fills all the intervals between the objects on it having visible extension, being material, and capable, as such, of being felt, analysed, weighed, and even, though it is generally spoken of as invisible, *seen* under certain conditions. But the laws of the pressure of an elastic fluid, which it is, and of the action of the earth's attraction on it, have led many philosophers to the conclusion that at a certain distance from the earth's surface, about a hundredth part of its diameter, or nearly eighty miles, the atmosphere entirely ceases, and the question remains, Are the intervals between those apparently detached points of material existence, which we can perceive only by the sense of sight, absolutely void, or filled by a form of matter which we cannot so perceive? There are some reasons why we should suppose that they are so filled. The first is solely applicable to that portion of space which is occupied by the solar system. The bodies revolving round the sun are of two kinds: planets, whose density (i.e. whose mass in proportion to their magnitude) is considerable; and comets, whose density is often very small, i.e. whose magnitude is great, but whose mass is inconsiderable. Hence comets afford a more delicate test, as it were, of any possible resistance, than planets do; and Encke, from an elaborate discussion of the movements of a particular comet, announced that the acceleration of its motion was due to a resistance in space, the resistance of course increasing the sun's power over its mass. Such a medium must necessarily be of extreme tenuity.

Another reason for supposing space to be full of matter is not limited in actual deduction to the solar system only, and left to be applied analogically to the remainder—the immeasurably greater remainder—of the universe, but applies to all the universe that is known to us. It is this: All philosophers are now agreed that light is not a material substance, but an affection of matter; i.e. that without material existence light could not exist—without continuous material existence light could not be transmitted; a vacuum, a break in the continuity, would be an impermeable screen of darkness between a luminous object and an observer. A necessary inference from this is, that all space between the earth and the most remote star that has ever been observed from it, must be filled by a material medium by which the light of that star has been transmitted—that all the universe known to us is filled by such a medium. What is the nature, then, of this material packing of the universe? Is it one already known to us, or one that we must imagine only? One opinion is, that it is a peculiar substance called *ether*, specially adapted for the transmission of light, which not only pervades all the regions of space not occupied by any other material object, but also, in different degrees, other material objects, such as the atmosphere, glass, &c., producing the phenomena of transparency, translucency, and the like; and that it, and it alone, has the power of transmitting luminous undulations. Another opinion is, that the atmosphere which surrounds our globe is merely the condensation, due to the earth's

attraction, of a universal atmosphere which fills space and transmits the undulations of light without the assistance of any supplementary ether, as many other forms of matter transmit and otherwise deal with them. Of course, if this latter opinion be held, the opinion that the atmosphere *entirely ceases* at eighty miles from the earth's surface must be erroneous; and though the most delicate means that we possess would fail to detect any air at all above that height, it may still exist, just as well as an ether the existence of which we are as little able to ascertain experimentally. It has been objected to the theory of a universal atmosphere, that if it were true there would be a sensible atmosphere surrounding the moon, which, if it amounted only to the thousandth part of the density of the atmosphere of the earth, would be detected by certain astronomical observations. However, the atmosphere which would, on this hypothesis, be due to the moon's attraction, would be only of the density of the earth's atmosphere some six thousand odd miles above its surface, or nearly six thousand miles above the point at which it becomes utterly impossible for us to detect the existence of air by any means in our power.

The question of sensible atmospheres, i.e. atmospheres whose existence we can observe from the earth, surrounding the moon and the planets, on the supposition of a universal atmosphere, is so dependent on conditions, such as the temperature of the body, the nature of the matter of which it is composed, &c., of which we are and must always be ignorant, that no satisfactory answer to it can now be arrived at.

As to the infinity of physical space, or the infinity of actual material existence, all that we can say is, that however far we advance (and we have advanced a great deal) in the power of discerning distant objects, we have uniformly found new objects to discern, and we have, therefore, good analogical reason for supposing that no limit can be assigned to their still further existence. This view of what is commonly called the infinity of space is further supported by the fact that metaphysical space, as a conjugate of material existence, in no way precludes the possibility of its infinite extension.

Space Lines. In Printing, thin pieces of type metal, cast to various thicknesses and different lengths, and not so high as type, to put between and increase the width between the lines. They are generally called *leads*.

Space Rules. In Printing, fine lines, cast type high, generally cast to a 4-to-pica lead in thickness, and to any length required. They are used in setting up tabular matter.

Spacing. In Printing, the adjustment of the distance between the words in a line, so that there shall not be any glaring disproportion.

Spadaite. A hydrated silicate of magnesia, found in red translucent masses at Capo di Bove, near Rome. Named after Signor Spada.

Spadix. In Botany, a form of inflorescence in which the flowers are arranged around a fleshy rachis, and enclosed within a kind of bract called a *spathe*, as in Palms and Araceous plants.

Spahis or **Sipahis.** A part of the Turkish cavalry were so called. The word has the same derivation with Sepoy.

Spalacotherium (Gr. σπάλαξ, *a mole*, and θηρίον, *a beast*). In the Purbeck beds at Swanage have been found remains of a small insectivorous mammalian, which exhibits the character of having each of the teeth divided into three pointed cusps adapted for crushing the *elytra* (wing-covers) of the *Coleoptera* or beetles which abounded in the upper oolitic beds. The dentition offers most affinity to the extinct *Amphitherium* and *Dromatherium*, and the existing *Chrysochloris*.

Span (Ger. spanne). In ordinary language, this word signifies a measure taken from the space between the thumb and the middle finger, both being extended. In Architecture and Engineering, it is applied to the extent or spread of an arch between its piers or abutments.

Spanaemics (Gr. σπανός, *poor*, and αἷμα, *blood*). Medicines which are supposed by long-continued use to impoverish the blood.

Spandril (Ital. spandere, *to spread*). In Architecture, the space above the flanks, or the haunches of an arch, or vault, above the intrados, and not higher than the crown of the arch.

Spaniolite. A name given to the Grey Copper-ore containing quicksilver.

Spanish Chalk. A variety of Steatite or silicate of magnesia. It is also called *French Chalk*.

Spanish Juice. The extract of the root of the Liquorice, *Glycyrrhiza glabra*.

Spanker or **Driver.** The name of the gaff sail set on the mizen mast of a ship of three masts, or on the mainmast of a smaller vessel.

Spanner. An iron instrument used in the manner of a lever to tighten the nuts upon screws. There is usually a notch at either end of the spanner, to suit nuts and screw-heads of different sizes.

Spar (Ger. spath). A Mineralogical term applied to certain crystallised substances which easily break into cubic, or prismatic, or other fragments with polished surfaces; hence, also, the term *spathose*, applied generally to minerals of a sparry fracture. The term *spar* is commonly used by miners to denote crystalline quartz; by quarrymen it is applied indifferently to quartz and calcareous spar.

Spar, Fluor, or **Derbyshire.** Fluoride of calcium. [Fluor Spar.]

Spar, Heavy. Sulphate of Baryta. [Barytes.]

Spar, Iceland. Transparent rhombohedral carbonate of lime. [Iceland Spar.]

Spars. In Architecture, a term, now almost obsolete, denoting the common rafters of a roof, as distinguished from the principal rafters or other timbers.

Sparable Tin. A name given in Cornwall to small crystals of Tin-stone, from their imaginary resemblance to the particular kind of nail called a *sparable*. They are found at Huel Harris, Huel Owles, and elsewhere, near Camborne.

Sparoids. The name of a tribe of Acanthopterygian fishes, of which the genus *Sparus* is the type. The palate is edentulous, but the jaws are generally well armed with teeth: sometimes these are all of a conical form, adapted for killing and lacerating: sometimes they are all rounded and obtuse, fitted for bruising. In some species, the anterior teeth are shaped according to the laniary type, and the posterior ones are grinders; in others, the anterior teeth resemble the human incisors. The genera of Sparoid fishes are founded chiefly on these dental modifications.

Sparrow (A.-Sax. speara). The name commonly applied to the species of PASSER, Linn. (*Pyrgita*, Cuv.), which nestles upon buildings, and is termed *house-sparrow* (*Pyrgita domestica*).

Sparrow Hawk (A.-Sax. spearhafoc). The name of the *Falco nisus* of Linnæus, *Accipiter fringillarius* of Ray; which latter name is retained in modern ornithology for the subgeneric denomination of this small Raptorial bird.

Sparry Iron-ore or **Sparry Iron-stone.** Native carbonate of iron, composed (when pure) of 37·93 per cent. of carbonic acid and 62·07 protoxide of iron; but often containing admixtures of oxide of manganese, lime, magnesia, &c. This variety of iron-ore occurs in this country chiefly in Cornwall, and in the north-western parts of Devonshire and Somersetshire, where it is frequently associated with Copper Pyrites. A variety of crystalline forms may be noted at Fowey Consols, and at Buckler's Mine near St. Austell. In Styria, Carinthia, and the adjoining countries, Sparry Iron-ore forms extensive tracts, extending along the chain of the Alps into Austria on one side and into Salzburg on the other. Most of the Styrian steel is manufactured from the immense bed of ore which occurs at Erzberg between Eisenez and Vordernberg. At Samorostro in Spain, a hill, altogether composed of this ore, has been worked for ages.

Spartium (Gr. σπαρτίον, *a small cord*). The generic name of the well-known Spanish Broom, which differs from our native broom, *Sarothamnus*, in the calyx being split above, and thus having two lips instead of one. The plant is widely spread over the Mediterranean region, and has been cultivated in British gardens for upwards of three hundred years. The growth is like that of the common broom, but the green polished twigs are terete and rush-like, instead of angular. The handsome yellow pea-flowers, arranged in racemes at the ends of the twigs, are highly perfumed, and very attractive to bees.

By macerating the twigs a good fibre is obtained, which is made into thread in Languedoc, and into cord and a coarse sort of cloth in Dalmatia. The flowers are said to afford a yellow dye, and the seeds in large doses are emetic and purgative, and sometimes used in dropsy like those of the common broom.

Spasm (Gr. σπασμός, *a cramp*). An involuntary contraction of the muscles, generally attended by pain.

Spatangus (Gr. σπάταγγος). The name of a genus of *Echinidæ*, or sea-urchins, having the mouth situated laterally, and but four rows of pores.

Spathe (Gr. σπάθη). In Botany, a large and coloured bract situated at the base of a spadix, enclosing the latter, and supposed to perform the office of corolla.

Spathose Iron-ore. [SPARRY IRON-ORE.]

Spatulate (Lat. spatula, *a broad knife to spread salve with*). In Zoology, when a substance or part of an animal is flattened, and broader and rounder at the apex, narrow at the base.

Spawn. In Natural History, this term is commonly applied to the eggs or ova of those oviparous animals which exclude them in a mass, either separate, as in most osseous fishes, or enveloped in an albuminous covering, as in frogs, toads, and many molluscs.

Speaker. The presiding officer in each house of parliament is so termed.

In the House of Lords, the lord chancellor or lord keeper of the great seal acts as Speaker; but, if there be no such person, the crown may appoint a Speaker by commission. At all times there are deputy Speakers appointed by commission to officiate during the absence of the Speaker, and if there be no Speaker or deputy Speaker, or none present, the House may elect. The Speaker of the House of Lords is not necessarily a peer, and in several modern instances (as in the case of Sir Frederick Thesiger, March 1, 1858) a lord chancellor has sat as Speaker before his creation as a peer. The Speaker of the House of Lords puts the question and transacts other formal business, but he has no more authority in keeping order or controlling the debates than any member of the House, the appeals on points of order being always made to the Lords present, generally. He may (if a peer) speak and vote, but he has no casting vote; in case of equality of division, the non-contents prevail.

In the House of Commons, the office of Speaker is of much more importance than in the Lords. The Speaker is chosen by the Commons at the desire of and subject to the approbation of the crown, and in rank takes precedence of all commoners. He presides over the deliberations of the House and enforces order. As *mouth of the House*, he communicates its resolutions to others, conveys its thanks, and expresses its censure. He issues warrants

to execute the orders of the House for the commitment of offenders, for the issue of writs, for the attendance of witnesses, and for other purposes, and transacts a great variety of other formal business. The Speaker cannot speak or vote except in committee (when he is out of the chair) or in case of an equality of votes, when he exercises the privilege of giving a casting vote. He has been enabled by statute to issue warrants to make out writs for new elections during a recess. Formerly there was no regular provision for the absence of the Speaker, and various expedients had been adopted on occasions of his indisposition, but a deputy Speaker may now be appointed. (Stat. 18 & 19 Vict. c. 84.) (May's *Parliamentary Practice.*) [PARLIAMENT.]

Speaking Trumpet. [TRUMPET.]

Spear (Ger. speer, Lat. sparus). A weapon consisting of a pointed blade at the end of a long shaft. It is one of the earliest known weapons.

Special Case. In Law, the statement, in a compendious form, of the facts upon which any question of law or equity arises for the purpose of obtaining a judicial decision thereon. This may be done in many cases both at common law and in chancery, when there is no dispute as to the *facts*, and the only contention between the parties relates to a matter of law or equity.

Special Constables. Constables appointed for particular occasions, as to execute a warrant or to assist in preserving the peace. (41 Geo. III. c. 78; 1 & 2 Wm. IV. c. 41; 5 & 6 Wm. IV. c. 43.)

Special Jury. A jury consisting of persons of a certain station in society, as esquires or persons of higher degree, or bankers or merchants. (3 Steph. *Comm.* 617.) [JURY.]

Special Pleader. In Law, one who draws common law pleadings. [PLEADING.] The term is particularly applied to persons who devote themselves to that line of practice without being either attorneys or barristers. They are compelled by statute to take out an annual certificate similar to that taken out by attorneys.

Special Verdict. A finding by the jury of the naked facts of the case, leaving to the court the application of the law, on which the ultimate entering of the verdict for one side or the other may depend.

Specialty. In Law, any instrument in writing under seal. Specialty creditors are those who have their debts secured to them by deed, in opposition to creditors on simple contract. The advantages of the former security are, that it has priority in the distribution of assets in some cases, and that specialty debts in general are not extinguished by the Statute of Limitations, until the lapse of twenty years, whereas simple contract debts are extinguished in six years.

Specie. A term used for gold and silver coin, in contradistinction to *paper money*.

Species (Lat.). In Logic, a predicable which is considered as expressing the whole essence of the individuals of which it is affirmed. The essence of an individual is said to consist of two parts: 1. The material part, or genus; 2. The formal or distinctive part, or difference. The genus and difference together make up, in logical language, the species. It is obvious that the names *species* and *genus* are merely relative; and that the same common terms may, in one case, be the species which is predicated of an individual, and in another case the individual of which a species is predicated: e.g. the individual, Cæsar, belongs to the species man; but man, again, may be said to belong to the species animal, &c., as we contemplate higher and more comprehensive terms. A species, in short, when predicated of individuals, stands in the same relation to them as the genus to the species, and when predicated of other lower species, it is then, in respect of these, a genus, while it is a species in respect of a higher genus. Such a term is called a *subaltern species* or *genus*; while the highest term of all, of which nothing can be predicated, is the *summum genus*; the lowest of all, which can be predicated of nothing, the *infima species*. The difference which, together with the genus, makes up the species, is termed the *specific difference*. [LOGIC; PREDICABLE.]

SPECIES (Lat.). In Natural History, certain groups of individuals, continued or reproducible, with characters, as far as human knowledge of them extends, so fixed as to be specified, are called, in Mineralogy, Botany, and Zoology, *species*.

The definition of such species varies in those three kingdoms of nature; nor has any been proposed which is equally applicable to the different grades of organisation manifested in the series of animals and of plants.

The 'distincta propagatio ex semine' of Ray reaches a long way down, but not to the bottom of the vegetable kingdom.

'The sum of organisms born the one of another, or of common parents, and of all such as resemble their parents as much as they resemble one another,' is applicable to the vast proportion of the Règne Animal known to Cuvier; but many exceptions to his definition of a *species* have since been brought to light.

Lamarck's more concise definition, as 'a collection of like individuals, produced by other individuals equally like them,' is equally affected by the phenomena of parthenogenesis. Cuvier, indeed, qualifies his definition by stating: 'Although organisms produce only bodies similar to themselves, there are circumstances which, in the succession of generations, alter, to a certain point, their primitive form.' (*Tableau Elèmentaire de l'Histoire Naturelle des Animaux*, 8vo. 1798, p. 9.)

One main aim of his successors is, and long will be, to determine that point; or whether there be, indeed, any such at which the mutation of a species necessarily stops. The observed grades of departure from specific type are termed *varieties*, and the degree of variation

in the offspring from the parent appears to be greatest in the lowest organisms. Consequently the definition or recognition of a *species* of Foraminifer, or Brachiopod, e.g., is much less easy than of a bird or a mammal.

Scanty observations on highly organised animals had shown that, when a male and female of different kinds interbred, the hybrid offspring were less fertile in some instances than in others. Thus the offspring engendered between the two kinds of equine animal, called *horse* and *ass*, being barren as a rule, was called a *mule*; and the parents were determined to be *species* under the names *Equus caballus* and *Equus asinus*. The hybrids produced from dog and jackal were found to be fertile (at least in a greater degree) inter se, and accordingly were pronounced to be *varieties*. There is evidence, indeed, that the dog, or some dogs, have been derived from jackals.

In proportion to the degree of man's sovereignty over lower species, is the number and kind of varieties which he obtains from them.

Food diversified in kind and abundance; *medium of existence* more or less cold, or more or less moist; degrees of exposure to *light*; vestures added to natural clothing; modifications of *exercise*; and limitations of *locomotion*, are among the causes of varieties defined by Cuvier, and of which he points out their respective effects. To these influences, man adds the more efficient one of selecting varieties, however produced, to breed from. The range of such departures from the primitive or wild type seems much greater than in the series of the wild species of a genus. But the breeds of dog, horse, ox, sheep, pigeon, fowl, so produced, are fertile inter se.

Many observations make it probable, but more are needed to prove, that, when freed from man's thraldom and care, such breeds or varieties die out or revert to the primitive type.

The inherent capacity of an animal for modification varies in different species.

To whatever degree, under the above-named influences, it attains, such changes of form and structure induce corresponding changes in action: the more frequent employment of certain parts or organs usually leads to a proportional increase of size in such parts; and, as the increased exercise of one part is usually accompanied by a corresponding disuse of another part, such disuse, by inducing a degree of atrophy, concurs with the opposite in forming another element in the mutation of organic forms. Next follows the hereditary tendency to transmit to offspring characters of variation acquired by the operation of external and internal influences on the parents. Finally, is to be added the occurrence, in offspring, of parts, proportions, or powers not traceable to any of the above influences upon parents, and called *accidental varieties*, proceeding, in some instances, to such degrees of departure from specific type as to have received the name of *malformations* and *monstrosities*. The influence of the above various conditions in the origin of species, with the postulate of illimitable time for their continued operation, forms a characteristic part of the work by Lamarck entitled *Philosophie Zoologique*, 8vo. 1809.

The principles, based on rigorous and extensive observations, which have been established since that date, and which have impressed upon the minds of the most exact reasoners in biology the conviction of a constantly operating secondary law originating species, are the following: the principle of irrelative or vegetative repetition, as manifested in lower organisations; unity of type, as exemplified by the power of determining homologous parts; the analogies of transitory embryonal stages in a higher animal to the matured forms of lower animals; the phenomena of parthenogenesis; the progressive departure from type, or from a more generalised to a more specialised structure, exemplified in existing species forming ascending steps in the scale of life, and also in the series of extinct species as they successively approach in time to the neozoic fossiliferous beds.

Owen, admitting, in 1849, that the succession of such species was due to the operation of natural laws or secondary causes, owns his ignorance of their nature or mode of operating in the production of species. (*On the Nature of Limbs*, 8vo. p. 86.) The author of the *Vestiges of Creation*, impressed by the results of embryological investigations since the time of Lamarck, speculates on the influence of premature birth, or of unduly prolonged fœtation, in establishing the beginning of a new specific form; and, in the main, inclines to inherent proneness to deviate from rule or pattern as a more potent cause of specific change than the influence of volitions or of outward circumstances.

The different degrees in which these circumstances operate on the different species or individuals subject thereto, attracted the consideration of naturalists in reference to the instances of extinction of species, progressively, and of late rapidly, brought within their cognisance. The study of this difference engendered the idea or perception of a 'contest for existence' being ever waged by species. Thus, in his account of the gigantic wingless birds of New Zealand, Prof. Owen, in 1850, expressed himself as follows: 'In proportion to its bulk is the difficulty of the contest which, as a living organised whole, the individual of such species has to maintain against the surrounding agencies that are ever tending to dissolve the vital bond and subjugate the living matter to the ordinary chemical and physical forces. Any change, therefore, in such external agencies as a species may have been originally adapted to exist in, will militate against that existence in a degree proportionate, perhaps in a geometrical ratio, to the bulk of the species. If a dry season be gradually prolonged, the large mammal will suffer from the drought sooner than the small one; if such alteration of climate affect the

quantity of vegetable food, the bulky herbivore will first feel the effects of stinted nourishment; if new enemies are introduced, the large and conspicuous quadruped or bird will fall a prey, whilst the smaller species conceal themselves and escape. Smaller animals are usually, also, more prolific than larger ones.

'The actual presence, therefore, of small species of animals in countries where larger species of the same natural families formerly existed, is not the consequence of any gradual diminution of the size of such species, but is the result of circumstances which may be illustrated by the fable of the "oak and the reed;" the smaller and feebler animals have bent and accommodated themselves to changes which have destroyed the larger species.'

The field of observation thus opened, by such instances of *natural rejection* of species, was one rich in the relations of outward circumstances and influences, not only in the preferential conservation of species, but in the fostering and favouring of varieties.

Baden Powell, admitting the influence of external conditions acting unfavourably, so as to cause the declension or extinction of a species, remarks: 'It is therefore a fair inference that, if favourable conditions were continued, and the variety were locally isolated from the rest of the species, it would become a permanent type or species.' (*Unity of Worlds*, 12mo. 1855, p. 376.)

Mr. Wallace, in 1858, assuming that varieties do arise in a wild species, speculates similarly on the influences which may either tend to the destruction of such variations from a specific type or to their adaptation to changes in surrounding conditions, under which they might be better calculated to exist, than the type form from which they had deviated. Arguing against the partial and inadequate views of Lamarck's hypothesis of the transmutation of species commonly given in popular English works or compilations, as Lyell's *Principles of Geology*, e.g., Mr. Wallace remarks: 'The powerful retractile talons of the falcon and the cat tribes have not been produced or increased by the volition of those animals; but among the different varieties which occurred in the earlier and less organised forms of these groups, those always survived longest which had the greatest facilities for seizing their prey.'

'Neither did the giraffe acquire its long neck by desiring to reach the foliage of the more lofty shrubs, and constantly stretching its neck for the purpose, but because any varieties which occurred among its antetypes with a longer neck than usual at once secured a fresh range of pasture over the same ground as their shorter-necked companions, and on the first scarcity of food were thereby enabled to outlive them.' ('On the Tendency of Varieties to depart indefinitely from the Original Type,' *Proceedings of the Linnean Society*, Aug. 1858, p. 61.)

Mr. Darwin expresses this view by the term *natural selection*, not as contrasted with the *natural rejection* instanced in a previous illustration, of which he seems not to have been aware, but with the *artificial selection* of breeds and varieties of domesticated species by man. The following is one of the illustrations of his idea. 'To give an imaginary example from changes in progress on an island: let the organisation of a canine animal which preyed chiefly on rabbits, but sometimes on hares, become slightly plastic; let these same changes cause the number of rabbits very slowly to decrease, and the number of hares to increase. The effect of this would be that the fox or dog would be driven to try to catch more hares; his organisation, however, being slightly plastic, those individuals with the lightest forms, longest limbs, and best eyesight, let the difference be ever so small, would be slightly favoured, and would tend to live longer, and to survive during that time of the year when food was scarcest; they would also rear more young, which would tend to inherit these slight peculiarities. The less fleet ones would be rigidly destroyed. I can see no more reason to doubt that these causes in a thousand generations would produce a marked effect, and adapt the form of the fox or dog to the catching of hares instead of rabbits, than that greyhounds can be improved by selection and careful breeding.' Many other ingenious conjectures are advanced in the work entitled, *On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, 8vo. 1859, in which the author states: 'The varieties or incipient species thus produced ultimately become converted, as I believe, into new and distinct species.'

As to the mode of operation of the converting cause, there is, at the bottom, much affinity of thought between Darwin and Lamarck. 'In North America the black bear was seen by Hearne swimming for hours with widely open mouth, thus catching, like a whale, insects in the water. Even in so extreme a case as this, if the supply of insects were constant, and if better adapted competitors did not already exist in the country, I can see no difficulty in a race of bears being rendered, by natural selection, more and more aquatic in their structure and habits, with larger and larger mouths, till a creature was produced as monstrous as a whale.' (*On the Origin of Species*, 1st edit. 1859, p. 184.)

Here, therefore, *internal impulse* is associated with *external circumstance*, abundance, viz., of attractive food, to illustrate the powers in nature which tend to select a form or variety for a transmutation of species. But actual observation leads to a recognition of a cause distinct from both *impulse*, *habitual action*, *change of the ambient medium*, or *external influence* of any kind. 'L'espèce est fixée sous la raison du maintien de l'état conditionnel de son milieu ambiant. Elle se modifie, elle change, si le milieu ambiant varie.' (Geoffroy St. Hilaire, 'Etudes Progressives,' *Mémoires de l'Acad. des Sciences*, t. xii. 1833.)

Taking the whale-kind as now known to zoologists, e. g., they seem to exemplify grada-

tional steps by which extreme modifications of cetacean structure, especially in the skull and dentition, are reached.

But such instances of freedom from the trammels of family likeness seem to be independent of external influences. The ocean has none of those diversities of condition which the dry land shows, and is exempt from the few which, in fresh waters, may be invoked to account for varieties in the species of fish. It is true that the trout (*Salmo fario*) of the mountain streamlet is small, while that of the wide river or wider lake is large; but no such differences in the theatre of life can be invoked to explain the origin of the dwarf porpoise or the giant whale—both have alike the unlimited seas for their range. The external conditions that could *select* the maxillary wall of the circum-narial basin in *Hyperoodon*, *Physeter*, or *Platanista*, are equally inconceivable. But the occasional departure from parental type, manifested by what at first might be called a *monstrous* proportion of the nasal or facial plate of the maxillary, may accord with the idea suggested by the observed steps in a gradation of such deviating developements.

If we were able to trace the successive steps backward in the formation, or creation by preordained law, of the species of *Cetacea* which now respectively propagate their kind, we might arrive at the primitive generalised form whence those species had diverged, and be able to determine whether such cetacean type had ascended from a marine reptile, or retrograded, as in Mr. Darwin's view, from a terrestrial mammal.

The tendency to such speculation is inevitable: the question of the first origin of living things will suggest itself in speculating on the origin of species.

Buffon supposed that certain type-forms were, at first, miraculously created, and that most of the so-called *species* exemplified degenerations from such originally perfect types: applying this view to the two hundred Mammalian species so well and eloquently described in his great work, *Histoire Naturelle générale et particulière*, &c. 4to. 1749–1789, tom. xiv. p. 328) he reduced them to about fifteen primitive stocks; but admitted also certain isolated created forms, which represented both species and genus.

Mr. Darwin, equally invoking a cause distinct and above any natural law, reduces its operation to narrower limits. 'I believe,' he writes, 'that animals have descended from, at most, only four or five progenitors, and plants from an equal or lesser number.' But he adds that 'analogy would lead us one step further, namely, to the belief that all animals and plants have descended from some one prototype,' and thus, 'that probably all the organic beings which have ever lived on this earth, have descended from some one primordial form into which life was first breathed.' (*Op. cit.* p. 486.) The idea of the direct creative act, so restricted, would appear to be that 'certain elemental atoms have been commanded suddenly to flash into living tissues.' (*Ib.*)

At this stage of speculation as to the origin of species, Lamarck is more logical, and his hypothesis more in accordance with the observed actual or existing grades of organised beings.

Lamarck reduces the prototypes of animals to two forms—the *vibrio* and the *monad* (*vers et infusoires*). The influences which operated though time unlimited led from one prototype though the molluscous, from the other through the articulate series, to the several forms of fishes; and thence, through the well-defined vertebrate pattern, up to man. With philosophic consistency, Lamarck sums up: 'Cette série d'animaux commençant par deux branches, où se trouvent les plus imparfaits, les premiers de chacune de ces branches ne reçoivent l'existence que par génération directe ou spontanée.' (*Phil. Zool.* vol. ii. p. 463.)

Every chemical constituent of cell-organisms (*Protozoa*) is found in the mineral kingdom.

Decomposition of mineral species, with water, supplied the first protoplastic matter, which, under the influence of light and heat, and by the conversion of electric, magnetic, or chemical, force into the vital mode, became aggregated into the form of the *cell*.

Organisms having thus originated, decomposition is but the transition from one life to another.

Nothing larger than the microscopic monad, or more complex than *sarcodé*, is produced by *heterogeny*. All higher organisms are derivatives of these.

If it be admitted that the sum of present evidence sways in favour of the becoming of species through the operation of actual powers, we may suppose that provision has also been made for the origination of those germs or germ-like organisms from which the higher species are derived. The nature of that provision, or the mode and conditions of operation whereby protoplasmic organic mucus becomes monadic, may worthily occupy the attention of microscopic observers and chemists.

The question now is a moot one between the heterogenists and the panspermists or those who hold that the germs of every kind of microscopic organism float in the atmosphere and develope in the infusions into which they may fall.

Specific. In Medicine, this term is applied to remedies the effects of which upon particular diseases are little liable to fallacy and uncertainty; hence cinchona is called a specific in certain kinds of intermittent fever, and mercury in syphilis, &c. A *specific character* is that which peculiarly and certainly distinguishes one thing from another.

Specific Gravity. [GRAVITY.]

Specific Heat. [THERMOTICS.]

Specific Performance. One of the main circumstances which led to the growth of the jurisdiction of the Court of Chancery was the power assumed by the chancellors to direct agreements to be performed, specifically, while

the common law courts would only give damages for the breach or non-performance of them, and this distinction still continues to exist in most cases. The Court of Chancery, however, will not decree specific performance of agreements, which it cannot conveniently superintend, such as contracts to construct buildings or works. A limited jurisdiction to order specific performance of agreements has recently been conferred on the county courts.

Specification. In Law, this term is especially used to signify the detailed description of an invention which it is sought to secure by a patent: this must be filed in Chancery and is open to public inspection. [PATENT, LAW OF.]

Spectacles (Lat. spectaculum, *a show* or *sight*, not *that which aids the sight*). An optical instrument, consisting of two lenses set in a frame, for assisting or correcting the defects of imperfect vision. The lenses are convex or concave, according to the nature of the defect to be remedied. In old age the form of the eye becomes flat, and the rays of light are consequently not refracted sufficiently in passing through it to meet on the retina and produce distinct vision. This defect is remedied by a convex lens, which produces a slight convergency of the rays before they enter the eye. Short-sighted people, on the contrary, require concave lenses; because, in their case, the indistinctness of vision proceeds from too great a curvature of the anterior portion of the eye, which causes the rays to meet in a point before they reach the retina—a defect which is remedied by giving the rays a slight divergency before they enter the eye.

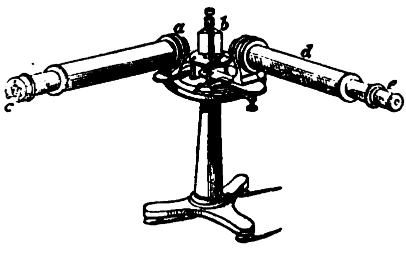
Spectacles appear to have been first used about the latter end of the thirteenth century; but the date and author of the invention are not certainly known, and have been much disputed. It seems most probable that the first hint of their construction and use was taken either from the writings of Alhazen, who lived in the twelfth century, or of Roger Bacon, who died about 1292. A passage in the *Opus Majus* of the latter renders it certain, at least, that he was acquainted with the use of crystalline lenses in magnifying minute or distant objects. (Smith's *Optics*, 'Remarks,' art. viii. 5—90.)

Spectre. In Zoology, a species of four-handed mammal (*Lemur spectrum*, Linn.), so called on account of its nocturnal habits, attenuated frame, long and skeleton-like limbs, and the gliding, stealthy, noiseless motion, by which it surprises a sleeping prey.

Spectroscope. One of the most powerful and important instruments of modern research, in which the analysis of light coming from various light sources is conducted by means of prisms.

If we allow a beam of light to fall on a prism at a proper angle, and if we examine the emergent ray with the naked eye, or let it fall on a plain white surface, we shall find that the ray has been refracted and analysed by its passage. If we wish to observe this phenomenon under the best possible conditions, we shall take care that the incident ray is small and *parallel*, and we shall examine the emergent rays by means of a telescope. The parallelism and reduction of the ray to a fine line is managed by an object-glass (a) near the prism (b), with a very fine slit (c) at its focus, the whole of this arrangement resembling a telescope. The tele-

Fig. 1.



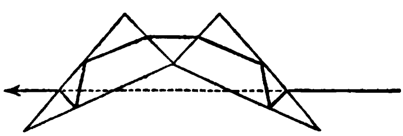
scope (d), by means of which the emergent ray is observed, may have its eye-piece (e) armed with a micrometer, if necessary, for observing the bright lines or dark bands in the spectrum. [SPECTRUM ANALYSIS.]

It will be seen from the figure that if one prism be used in this manner, the two telescopes will form an angle between them. This is the ordinary construction, but for some purposes it is convenient that they should have a common axis. Steinheil has constructed a spectroscope of this kind, in which three prisms are used, the direction of the ray being kept by means of external reflections. Hoffmann has constructed a differential prism with the same end in view. The best form of this kind is the *Herschel-Browning*, the principle of which will be easily seen from fig. 2. It is, in fact, a combination of two direct vision prisms, the smallest angle being determined by the formula—

$$2\,A = 1 - \frac{1}{\mu^2},$$

μ being the refractive index of the glass employed.

Fig. 2.



In fig. 1, we have supposed *one* prism only to be employed, but it is now usual to employ several, the rays being more opened out by each passage, so that a gradually increasing dispersion is obtained. In the instrument manufactured by Mr. Browning for the Kew Observatory, which is now employed in mapping the lines in the solar spectrum with a degree of perfection surpassing anything hitherto attempted, no less than nine prisms are used.

The dispersion may be also increased by using substances having a higher refractive

index than glass. Bisulphide of carbon is the substance usually employed; and as it is a highly volatile liquid, it is enclosed in hollow glass prisms.

In order to obtain the bright lines on the spectrum of the light emanating from any substance, the flame of a common spirit lamp, or a gas jet known as a *Bunsen's burner*, is placed before the narrow slit or knife edges. A small bead of the substance to be experimented on may be fused into a small loop of platinum wire. The wire being attached to a convenient support, the head should be brought to the front edge of the flame.

Some of the most important astronomical discoveries of the last few years have resulted from the application of the spectroscope to the telescope, the aid of the latter being called in to collect the light emanating from the distant stars and nebulæ. The light incident on the prism is rendered parallel, as in the ordinary arrangement, and the emergent rays are observed in the same manner, but a further refinement is required in this case. The image of a star formed at the focus of a good telescope is almost a point; its spectrum, therefore, would be a line, and in such a spectrum it would be impossible to distinguish any of the characteristic features. The point, therefore, is elongated somewhat at right angles to the plane of refraction by means of a cylindrical lens.

Messrs. Sorby and Browning have also arranged a modification of the spectroscope for use with the microscope. It is applied to the eye-piece of that instrument by means of direct vision prisms. It is applicable to opaque objects, and may also be applied beneath the stage. By its means the spectrum of the smallest object, or a particular portion of any object, may be viewed with the greatest precision and ease.

Spectrum (Lat. *an image*). In Optics, the name given to the luminous band produced on a screen or in the eye by subjecting a beam of light received through a small slit or hole, to decomposition by a prism. For the different colours and fixed lines visible in different spectra, see CHROMATICS; COMET; NEBULÆ; SPECTRUM ANALYSIS; STAR; and SUN; and for the refrangibility of the different rays, REFRACTION.

Spectrum Analysis. Every known substance gives out light if it be sufficiently heated. Daylight is supplied from the intensely heated matter of the sun; the artificial light of gas, oil-lamps, candles, &c., is emitted by white-hot particles of carbon; the luminosity even of lightning arises from the highly ignited nitrogen and oxygen of our atmosphere.

Light from various sources differs considerably in composition. The unaided eye is unable to detect differences of colour in the associated mass of rays that impinge upon the retina; it is only when that mass or pencil of rays is first passed through a prism that the eye can ascertain what particular rays are present and what absent. The prism has the power of decomposing a compound ray into its constituent rays; it bends each constituent ray out of its course to an unequal extent, so as to arrange them consecutively in a band. This band is called a *spectrum*. Thus a beam of sunlight is found to consist of rays of almost every conceivable shade of colour, the spectrum beginning with red, which is least bent out of its course, or least *refrangible*, passing through every tint of orange, yellow, green and blue, and terminating in violet rays which are the most refrangible. This spectrum of sunlight has long been familiar to us under other names. Thus, the pretty coloured appearances sometimes seen on the wall, ceiling, floor, and furniture of a room when the sun shines on the prisms of an ornamented glass chandelier are the spectra of beams of sunlight; the white rays are decomposed by the prisms and the thereby disassociated rays reflected from the objects in the room. Received directly into the eye, the effect is still more gorgeous. But the most magnificent spectrum that we are acquainted with, a combination, so to speak, of innumerable spectral bands placed side by side, is that which occurs when rain-drops are the reflecting and refracting media—the familiar but ever-glorious rainbow.

Thus, then, a prism has the power of analysing light, showing what are its constituent rays; the latter being termed a *spectrum*. The operation is that of *spectrum analysis*. But it is analysis in a more extended sense, for every element of our earth gives, when its vapour is ignited, rays which probably are peculiar to itself; if, therefore, a substance of unknown composition is intensely heated, and the light which it emits is examined by a prism, the colour and position of the rays which may be present indicate at once the composition of the substance.

This statement must, however, be somewhat qualified. Every element that has been examined certainly has a characteristic spectrum, but many have yet to be examined. Again, temperature seems to influence considerably the character of a spectrum. The spectrum of a compound containing two or more elements has been proved to be different from the spectra of its constituents if the compound be not decomposed by the heat applied. And, lastly, a method has yet to be devised by which a substance shall be so ignited that every element which it contains shall be vaporised with certainty, and the emission of light from it be sufficiently continuous to admit of practical recognition of its spectrum.

Four new metals have been discovered by spectrum analysis. Bunsen and Kirchhoff, in examining the spectra of certain residues of the evaporation of water from a spring (Durckheim), detected rays of a colour and position in the spectrum hitherto unobserved. Following up the research, they succeeded in isolating the two metallic elements cæsium and rubidium. Soon afterwards Mr. Crookes discovered thallium; indium being the last added to the list in this way.

Spectrum analysis has also thrown considerable light on the question of the constitution of the universe, new facts having been acquired concerning the sun, stars, nebulæ, and comets. Thus, to begin with the sun, the spectrum of sunlight, otherwise bright and brilliant throughout its whole extent, is separated into distinct parts by a large number of exceedingly narrow spaces apparently devoid of light. The appearance of this spectrum when thrown directly on the retina or reflected from a surface is that of light of all colours, from red to violet, traversed by numerous fine lines in a direction transverse to its length. Now, it is remarkable that the spectra of several of the elements are composed of bright rays identical in position with these dark spaces in the solar spectrum. The key to the interpretation of this fact has been obtained experimentally and is as follows: The light emitted by an incandescent body is sifted by passage through any ignited vapour, the ray or rays sifted out being precisely those which the ignited vapour itself emits. So, then, the light emitted by the photosphere of the sun is absorbed by the vapour of various substances in the sun's atmosphere, the only perceptible light which reaches our earth being that not so absorbed. The dark spaces in the solar spectrum being identical with the light emitted by certain ignited terrestrial metals, the inference is that the vapours of those metals exist in the sun's atmosphere. So far as examination has at present extended, these metals are ten in number, viz. sodium, potassium, magnesium, iron, chromium, nickel, calcium, barium, copper, and zinc. Hydrogen is also present in the solar atmosphere. This magnificent discovery is due to Kirchhoff. The analysis of starlight has shown that the stars are built on the same model as the sun, though the details vary in each star yet examined. The light of nebulæ and comets shows us, on the other hand, that those bodies are masses of glowing gas.

Speculation (Lat. speculatio, from speculor, *I watch*). In Commerce, a term employed, with some slight meaning of disapprobation, to designate such purchases as are made in hope that there will speedily be a rise in the price of the article bought, and thereupon a gain to the buyer. Speculation, then, is an anticipation on the part of a trader that demand will be excessive or that supply will be deficient. The former is the commonest cause of speculation and is generally the most liable to fallacy, since it is founded on the interpretation of the inclinations which affect others, or the powers which they possess of gratifying these inclinations, while the latter is more frequently founded on facts. Thus, for instance, in the early days of the gold discoveries in Australia, speculation took the form of exports to that region, and so excessive was the tendency and so great the glut that articles were frequently sold at less than the cost of freight; on the other hand, the speculative purchases of cotton during the continuance of the great American war were based on the anticipation of deficient supply, and were on the whole successful.

The function of the speculator, on the presumption that his action is governed on common prudence, and by as much foresight as possible, is, on the whole, beneficial to society. In appearance, he is at war with the general interests of mankind; in effect he serves them. He renders prices generally steady by his eagerness to buy when prices are low, and he enforces economy by withholding a portion of consumable commodities when scarcity occurs. In past times, the tendency to speculate in such commodities was checked by severe statutes, and it was only when these indirect advantages were detected that these repressive laws were repealed. Thus, Sir John Barnard's Act, passed about the middle of the last century, strove to prevent time bargains on the Stock Exchange, by disabling those in whose favour the bargain had turned out from recovering against the loser by legal process. The brokers met this disability by establishing a strict code of honour. But the public has gradually learned that these negotiations are of considerable utility by obviating the risk of great fluctuations in the price of securities. Of course this action of speculators is quite distinct from the occasional attempts made to force a panic in some stock or shares by the offer of fictitious sales. The most notable of these operations for a rise or fall, were the South Sea Bubble, the Mississippi scheme, and the tulip mania in Holland.

When the speculator purchases consumable articles on credit, his demand raises prices early, and, if his conjecture be correct, only anticipates a certain rise. Should his judgment be in error, he bears the loss; and if many speculators join in the same or similar ventures, the reaction involves an increased demand for bank credit. Speculative purchasers do not therefore, as some economists have supposed, increase the amount of convertible bank-notes, but sales consequent on the reaction do. This fact is of great importance in the theory of banking.

Speculum (Lat. *a mirror*). In Optics, the term *speculum* is usually appropriated to reflectors formed of polished metal; while the term *mirror* is used to signify a reflector of glass. For the focal distances and laws of reflexion of spherical specula, see REFLEXION; and for a description of the method of casting and polishing large specula for reflecting telescopes, see Sir W. Herschel's description of his telescope in the *Phil. Trans.* for 1795; Brewster's edition of Ferguson's *Lectures*; and the article 'Telescope' in the *Encyclopædia Britannica*. [TELESCOPE.]

Speculum Metal. Speculum metal, with which mirrors for reflecting telescopes are made, is an alloy of two parts of copper and one of tin; its whiteness is improved by the addition of a little arsenic.

Speech. [LANGUAGE; METAPHOR; POLYONYMY; SYNONYMY.]

Speed of Railway Trains. [RAILROADS.]

Speed of Steam Vessels. [STEAM NAVIGATION.]

Speeton Clay. A dark blue laminated clay with calcareous nodules, found near Scarborough in Yorkshire, belonging, it is believed, to the lower part of the cretaceous series. It contains fossils.

Speiss. An impure arsenide of nickel, obtained from the ores of cobalt and nickel in smalt-works.

Speldings. A Scotch term for dried and salted whitings.

Spell (A.-Sax. spel, *story* or *tale*). Any form of words, written or spoken, supposed to be endowed with magical virtues.

Spelt (A.-Sax. spelte, Ger. spelz). The *Triticum Spelta*, an inferior kind of wheat grown in some parts of the European continent.

Spelter (Dutch spiauter). The commercial term for zinc. [PEWTER.]

Sperm-cell. In Anatomy, the cells contained in the liquor seminis, in which are formed the spermatoa, or cells of developement of the spermatozoa.

Spermaceti (a word coined from the Gr. σπέρμα, *seed*, and κῆτος, *a large fish*). This substance concretes or crystallises spontaneously out of the oil of the spermaceti whale. It is purified first by pressure, then by fusion and boiling with a weak alkaline ley. When melted in masses, it concretes in crystalline plates of a silvery lustre and unctuous feel. It fuses at about 100°. It dissolves in boiling alcohol; and as the solution cools it separates in brilliant scales, to which Chevreul has given the name of *cetine*. Spermaceti differs from common fats in not yielding glycerine when saponified, but a peculiar base termed *ethal* $= C_{32}H_{34}O_2$.

Spermaceti Whale. [CACHALOT.]

Spermatic Chord. That part which, in Mammals having a SCROTUM, seems to suspend the testicles, and, in fact, contains their vessels, nerves, and ducts, with the surrounding muscular and connective tissue.

Spermatic Fluid. [SPERMATOZOA.]

Spermatoa (Gr. σπέρμα, and ᾠόν, *an egg*). The cells which stand in the relation of nuclei to the sperm-cells, and of developemental cells to the spermatozoa. Sometimes the sperm-cell contains a single spermatoon, sometimes several spermatoa, in which case the resulting spermatozoa often unite together and form a fasciculus, as, e.g., in the sparrow.

Spermatophora (Gr. σπέρμα, and φέρω, *I carry*). In Anatomy, cases of albuminous matter, in which the bundles of spermatozoa are packed; they are largest and most complex in the Cephalopods.

Spermatozoa (Gr. σπέρμα, and ζῶον, *animal*). The filamentary bodies developed in the semen, and consisting of an enlarged extremity called *body*, and a vibratile filamentary appendage called *tail*. Spermatozoa consist of an amber-coloured, highly refracting, homogeneous substance, like the hyaline nucleus of cells, and are formal modifications of the nucleus of the spermatoon. They are essential to impregnation.

Spermidium (Gr. σπέρμα). A kind of small seed-vessel, resembling a seed, and more commonly called an *achene*.

Sphacelus (Gr. σφάκελος). [GANGRENE.]

Sphaeristerium. [BALL.]

Sphaerosiderite or **Spherosiderite** (Gr. σφαῖρα, *a globe*; and σίδηρος, *iron*). A name given by Hausmann to a spheroidal and radiated variety of Sparry Iron-ore found in Greenstone, at Hanau in Western Germany; and in the circle of Jaslo in Austrian Galicia.

The name is also applied generally to the globular concretions of spathose carbonate of iron found in some amygdaloids or lavas. [SPARRY IRON-ORE.]

Sphaerulite or **Spherulite.** A term applied by some mineralogists to a variety of Obsidian or Pearlstone, which occurs in small rounded grains. [PEARLSTONE.]

Sphene (Gr. σφήν, *a wedge*, from the shape of the crystals). A titanate and silicate of lime (or a silicate of titanium, in which part of the latter is replaced by lime). It is found crystallised and sometimes in granular or foliated masses of a brown, grey, and yellow colour, near Tavistock and Tremadoc; in the Shetlands; at Cariglinneen, co. Down; and at Crow Hill near Newry.

Sphenoid Bone (Gr. σφηνοειδής, from σφήν). One of the bones of the head; so called from its being wedged in, as it were, amongst the other bones. It is of a most irregular shape, and very complicated in its processes and connections with the other bones. When removed, it is something of the figure of a bat with its wings extended. It is connected with all the bones of the skull, and with those of the palate, cheeks, and upper jaw. Homologically, the sphenoid of anthropotomy answers to seven bones, the basisphenoid, alisphenoids, orbitosphenoids, and pterygoids.

Sphere (Gr. σφαῖρα, *a ball*). In Astronomy, the concave expanse of the heavens, which, having no definite limit, appears to the eye as the interior surface of a sphere enclosing the earth, which is placed at the centre. The ancients gave the name of *sphere* to the orbits of the several heavenly bodies; thus, the sphere of Jupiter, the sphere of Saturn, the sphere of the fixed stars. In the Ptolemaic astronomy, the different spheres were supposed to be solid and transparent, moving about their common centre independently of each other, and each carrying its appropriate body along with it. [PTOLEMAIC SYSTEM.]

SPHERE. In Geometry, a solid body described by the revolution of a semicircle about its diameter; or it may be defined to be a body bounded by a surface of which every point is equally distant from a single point within the surface, called the *centre of a sphere*. If r denote the radius of the sphere, and x, y, z rectangular co-ordinates, the origin being at

the centre, the equation of the surface is $x^2+y^2+z^2=r^2$.

The following are some of the principal metrical properties of the sphere (for other descriptive properties, see SPHERICS): 1. The surface of the sphere is equal to four times the area of one of its *great circles*; i.e. of a section made by a plane passing through its centre. 2. The curve surface of any zone, or portion contained between two parallel planes, is equal to the curve surface of a cylinder of the same height with the height of the zone, or the distance between the planes, and of the same diameter with the sphere. Hence it follows that the whole surface of the sphere is equal to the curve surface of the circumscribing cylinder. 3. The volume of a sphere is equal to that of a pyramid whose altitude is the radius, and whose base is equal to the surface of the sphere; and hence the volume of the sphere is one-third of the product of its radius into its surface. 4. The sphere is equal to two-thirds of its circumscribing cylinder.

Let r denote the radius of the sphere, s its superficies, v its volume, and π the ratio of the semicircumference to the radius $= 3{\cdot}14159$; then since the area of a circle of which r is the radius is πr^2, the properties above stated give the relations which follow; viz.

$$s = 4\ \pi\ r^2 = 12{\cdot}56637\ \times\ r^2,$$
$$v = \tfrac{1}{3}\ r\ s = \tfrac{4}{3}\pi\ r^3 = 4{\cdot}18859 \times r^3.$$

Spherical Curvature. [CURVATURE, SPHERICAL.]

Spherical Excess. The excess, above two right angles, of the sum of the angles of a spherical triangle. [EXCESS, SPHERICAL.] If Δ denote the superficial area of the triangle whose excess estimated in circular measure is E, we have the simple relation $\Delta = \mathrm{E}\,r^2$, where r is the radius of the sphere. [SPHERICS.] According to Legendre's Theorem, if the radius of the sphere be very large when compared with the arcs of the spherical triangle, then each angle of the latter exceeds by one-third of the spherical excess the corresponding angle of the *plane triangle* whose sides are equal in length to the arcs of the spherical triangle. The area of this plane triangle being approximately the same as that of the spherical one, an approximate value of the spherical excess is readily obtained in geodetical measurements. With respect to the latter subject, however, we cannot here enter into details, and must refer the reader to published accounts of the British Ordnance Survey. In connection with the spherical excess there are two formulæ which, for the sake of reference, may here find a place. The first is known as Cagnoli's, the second as Lehuillier's Theorem.

$$\mathrm{Sin}^2\frac{\mathrm{E}}{2} = \frac{\sin s\,.\,\sin(s-a)\sin(s-b)\sin(s-c)}{\cos^2\frac{a}{2}\ \cos^2\frac{b}{2}\ \cos^2\frac{c}{2}}$$

$$\tan^2\frac{\mathrm{E}}{4} = \tan\frac{s}{2}\tan\frac{s-a}{2}\tan\frac{s-b}{2}\tan\frac{s-c}{2}.$$

As usual, a, b, and c here denote the sides of the spherical triangle, i.e. the angles which the arcs subtend at the centre of the sphere, and s denotes half their sum.

Spherical Indicatrix. [INDICATRIX, SPHERICAL.]

Spherics. In Geometry, the doctrine of the properties of a sphere considered as a geometrical surface. The section of a sphere by any plane is a circle which receives the name of *great circle* or *small circle*, as its plane passes or does not pass through the centre of the sphere. The diameter of the sphere which is perpendicular to a great circle is called the *axis* of the latter, as well as of all the *parallel* small circles; the extremities of this axis are the *poles* of the series of circles, and any great circle through these poles is called a *secondary circle*; the latter cuts the original or *primary* great circle and all its parallels at right angles. The angle between any two secondaries (sometimes called a *spherical angle*, though there appears to be no necessity for the distinction) is measured by the arc which they intercept upon the primary. The poles of these secondaries lie on the primary, and the inclination of the former circles may also be measured by the arc of the latter circle between two of their poles.

The shortest line on the sphere by which two given points can be joined is the arc of the great circle which passes through those points, and is less than a semicircle. Three points on the sphere form a *spherical triangle* whose sides are the shortest lines (great circles) which join the points; these sides are proportional to the angles which they subtend at the sphere's centre. The three poles of the sides of a spherical triangle which lie in the same hemisphere as the triangle itself, form the *polar triangle*. The latter and the original are also called *supplemental triangles*, since a side of the one is the supplement of the corresponding angle of the other. Spherical triangles have many properties in common with plane triangles; for instance, the greater angle always subtends the greater side, and if two angles are equal, so are the opposite sides, and the triangle is *isosceles*. The angles of a spherical triangle, however, are together *greater* than two right angles; the *excess* is a measure of the superficial area of the triangle. A right-angled spherical triangle is one which has a right angle; the supplemental triangle in this case has one of its sides equal to a quadrant, and is termed *quadrantal*. There are also bi-rectangular and bi-quadrantal triangles, as also *tri-quadrantal* ones, the sides of which are all quadrants and the angles all right angles. The spherical surface enclosed between two great semicircles is called a *lune*; its area clearly bears the same ratio to that of the whole sphere which the *angle of the lune* bears to four right angles. From this is deduced the important theorem that the *surface of a spherical triangle has to that of the hemisphere the same ratio which the spherical excess has to four right angles.* For

further properties of the sphere, see SPHERE and TRIGONOMETRY.

Sphero-conic. The section of a sphere by a quadric cone having its vertex at the centre. Such a section obviously consists of two closed and perfectly symmetrical curves in the opposite hemispheres determined by one of the principal planes of the cone. Either of these closed curves may be regarded as a *spherical ellipse*. The same sphero-conic, however, may be regarded as a *spherical hyperbola* in either of the hemispheres into which the sphere is divided by one of the principal planes which cut the cone. The cyclic planes of the cone cut the sphere in the *cyclic arcs of the sphero-conic*, which latter are the analogues of the asymptotes of a plane conic. The focal lines of the cone determine on the sphere the *foci of the sphero-conic*. The great circles of which the several points of a sphero-conic are the poles, envelope the *reciprocal sphero-conic*; of which latter the foci and cyclic arcs are respectively the poles and polars of the cyclic arcs and foci of the original sphero-conic.

The properties of sphero-conics are in many respects precisely similar to those of plane conics. For instance, the sum (or difference) of the arcs (of great circles) joining the foci to any point of a sphero-conic is constant, and the two tangents from any point to a sphero-conic are equally inclined to the arcs which join that point to the two foci. The reciprocals of these theorems show that every tangent to a sphero-conic forms with the cyclic arcs a triangle of constant area, and that the segments are equal which a sphero-conic and its cyclic arcs intercept upon any secant. An elaborate memoir on sphero-conics, by Chasles, will be found in the *Trans. of the Royal Acad. of Brussels*, vol. vi.; it was translated (with additions) by Dr. Graves of Dublin, and published in 1837. A résumé of this memoir, but with original demonstrations, is given by Dr. Salmon in his *An. Geom. of Three Dimensions*.

Sphero-polar Reciprocal. [POLAR RECIPROCAL.]

Spherograph. An instrument invented for the practical application of spherics to navigation. By its aid any possible spherical triangle can be constructed without dividers or scales.

Spheroid (Gr. σφαιροειδής). In Geometry, a solid generated by the revolution of an ellipse about one of its axes. If the generating ellipse revolves about its major axis, the spheroid is *prolate*, or oblong; if about its minor axis, the spheroid is *oblate*.

Let $2a$ be the axis of revolution, and $2b$ the diameter of the generating ellipse perpendicular to the axis; then the origin of the co-ordinates being at the centre, and x being taken on the semi-axis a, the equation of the surface of the spheroid is

$$\frac{x^2}{a^2} + \frac{y^2 + z^2}{b^2} = 1.$$

Let k^2 denote the ratio of the difference of the squares of a and b to the square of a; i.e. make $a^2 k^2 = a^2 - b^2$, and put $\pi = 3{\cdot}14159$: then the whole surface S of the spheroid is expressed by the following series, in which the upper signs are to be used if the spheroid is oblong (i.e. if a is greater than b), and the under signs if the spheroid is oblate: viz.

$$S = ab\left(1 \mp \frac{1}{2.3}k - \frac{1}{2.4.5}k^2 \right.$$
$$\left. \pm \frac{3}{2.4.6.7}k^3 - \&c.\right)$$

The volume of the spheroid, expressed by $\frac{4}{3}\pi a b^2$, is two-thirds of that of the circumscribing cylinder.

An oblate spheroid being approximately the figure of the earth, its properties are of great importance. Referring the reader desirous of full information on the subject to Airy's article in the *Ency. Metrop.* or to the published account of the Ordnance Survey, we will here merely add three formulæ, relative to the curvature of the earth, which are sometimes useful.

Let a be half the polar axis, b the radius of the equator, e the ellipticity, or a number such that $b = a\ (1 + e)$ [ELLIPTICITY], and l the given latitude. Also, let r be the radius of curvature in the direction of the meridian, r' the radius of curvature in the direction perpendicular to the meridian, and R the radius of curvature of a normal section, making with the meridian an angle $= \theta$; then

$$r = a\,(1 - e + 3\,e \sin^2 l) \quad . \; . \; . \; (1)$$

$$r' = a\,(1 + e + e \sin^2 l) \quad . \; . \; . \; . \; (2)$$

$$R = \frac{r\,r'}{r \sin^2\theta + r' \cos^2\theta} \quad . \; . \; . \; . \; (3)$$

Spheroidal Condition of Liquids. When a few drops of a liquid are allowed to fall on a highly heated smooth surface, they are not at once converted into vapour, but, rebounding, roll over the hot surface without moistening it, in the shape of flattened spheroids. This, at first sight, extraordinary and anomalous phenomenon has been called the spheroidal condition of a liquid. After the temperature of the heated body has sunk below 300° Fahr., in the case of water the liquid will no longer remain in the spheroidal state, but boils and disappears in the ordinary way. This phenomenon was first described by Eller at the Academy of Berlin in 1746; ten years later it was studied by Leidenfrost, by whose name it is frequently called; since then many other experiments have been made upon it, but most of our knowledge of this curious property of liquids was derived about twenty years ago from the investigations of M. Boutigny, who first gave to it the name by which it is now known. When in the spheroidal condition, the liquid is not in contact with the hot surface, but is lifted up and sustained by the vapour which is rapidly generated from that portion of the drop nearest the heated body. From this cause, if a dish

perforated with fine holes be used, the liquid will not run through so long as it remains in the spheroidal state. M. Boutigny and others believe that the space, which can easily be seen to exist, between the liquid and the hot plate, is due to the repulsive force of heat; but it is probable that this repulsion would not be exercised at sensible distances. Moreover, in order to assume the spheroidal state it is necessary that the substance be volatile, and if this be the case solids as well as liquids can become spheroidal. The cause of the phenomenon is, therefore, to be found mainly in the developement of vapour from the under surface of the spheroid: cushioned on this vapour, it is moulded by the resultant action of gravity and cohesion.

The best way to obtain the spheroidal state is to heat a little metal dish or spoon to redness, and then to pour in a little water; no ebullition occurs, but the water skips about in little globules or gathers into a mass with a beautifully crimped border; it is evidently out of contact with the vessel, and from the bad conducting power of the vapour only slowly evaporates, unless, however, the heat be withdrawn, and then it instantly flashes into steam. The temperature of the spheroid is a little below the boiling point of the liquid; with water it is about 206° Fahr.

The passage of a large body of water from the spheroidal into the ordinary condition, and the consequent sudden copious generation of steam, has been assigned as a probable cause of the explosion of over-heated steam boilers. A red-hot dish thrown on water is lifted out of contact with the latter, until it has cooled down so far that the tension of the vapour generated is insufficient to sustain the dish. By roughening the surface, or, better, coating it with certain oxides, the conversion of a liquid into the spheroidal state may partially or wholly be prevented. Owing to the separation from the hot surface, due to the spheroidal condition, water or even mercury may be frozen in a red-hot crucible by a bath of solid carbonic acid and ether. From the same cause laundresses know when their irons are hot enough, by the saliva rolling off them, or their wetted finger being unburnt when the iron is touched.

It is owing to the protective influence of the vapour shell surrounding a liquid in the spheroidal state, that a moistened hand can be plunged into molten lead or iron with perfect impunity. Some of the escapes from the fiery ordeal may thus be explained. To repeat the experiment, the molten lead should be as hot as possible, and the finger or hand should be dipped in liquid ammonia before it is plunged in the red-hot mass.

Spherometer (Gr. σφαῖρα, and μέτρον, *measure*). In Physics, an instrument for measuring with great precision the thickness of small bodies, the curvature of optical glasses, &c.

Spherosiderite. A variety of spathose iron-ore. [SPHÆROSIDERITE.]

Spherulite. A variety of Pearlstone. [SPHÆRULITE.]

Sphex (Gr. σφήξ, *a wasp*). A generic name restricted to those burrowing wasps which live in single pairs, and have the wings always outstretched. The female usually places by the side of the eggs she has laid the bodies of insects, killed or paralysed, to serve as food for the grub when hatched.

Sphigmometer (Gr. σφιγμός, *a binding tight*). An instrument for counting the arterial pulsations.

Sphincter (Gr. σφιγκτήρ, from σφίγγω, *I bind tight*). A term applied by anatomists to several muscles which close or contract the orifices which they surround.

Sphinx. In Entomology, the generic name of the Hawk-moths, so called from their size and power of flight. The death's-head moth (*Acherontia atropos*), the privet moth (*Sphinx ligustri*), the humming-bird moth (*Macroglossa stellatarum*), are indigenous examples of the genus, now raised, as the names quoted imply, to the rank of a family (*Sphingidæ*) including many other modern generic sections. The attitude of the caterpillar of the hawk-moths, resembling that of the fabulous sphinx of Egyptian sculpture, suggested to Linnæus the generic name.

SPHINX. The name and figure of this mythical being have been commonly regarded as originating in Egypt; and there is no doubt that the impression made by the art and the theology of that ancient kingdom on the minds of the Greeks, led them in course of time to trace to Egyptian soil the growth of Hellenic art and science. Thus, the sight of the colossal figures at Sais, which Herodotus (ii. 175) terms Ἀνδρόσφιγγες, or male sphinxes, led him probably to the conclusion that the Greek Sphinx was simply borrowed from that of Egypt. He was not less mistaken in this supposition than on the other points of ethnology and mythology in which he was led astray by the impudent assumptions and falsehoods of Egyptian priests. The word *sphinx* is genuinely Greek, being connected with σφίγγω, *to bind fast*; and thus the Sphinx is preeminently the *throttler*, and answers precisely to the Sanscrit ahi, *the snake*, from the root *anh*, to press together or choke, which reappears in the Greek ECHIDNA, and the Latin anguis. This snake or serpent is the Hindu monster VRITRA, who is engaged in deadly strife with Indra, and who, like the Sphinx, brings drought upon the earth, until he is smitten by the spear of the sun-god, as the Theban Sphinx is smitten by ŒDIPUS. This battle, which in India and Greece is wholly or almost wholly physical, assumed on Iranian ground a moral aspect, and became the internecine struggle between AHRIMAN and ORMUZD [DUALISM], the strife between spiritual good and evil. In Western mythology, the same conflict is set forth in the battle of Apollo with PYTHON, of SIGURDR with Fafnir, of Perseus with the Libyan dragon, of Bellerophon with the CHI-

MÆRA. These legends show, further, that the idea of the Sphinx is not more Egyptian than the word. The Sphinx, like Echidna, has the head of a woman with the body of a beast, and shares with Typhon the claws of the lion, the wings of a bird, and the serpent's tail. In short, the resemblance of the Hellenic Sphinx to the so-called Sphinx of Egypt is at best very distant; and the name is found in Greek mythology at a period long preceding that in which Egypt was opened to Greek merchants or travellers. In the Hesiodic *Theogony*, the Sphinx is a daughter of ORTHROS and Chimæra, and a granddaughter of Typhon and Echidna; and the form Phix, which the name assumes in this poem, serves only to indicate the connection of the Greek σφίγγω with the Latin *figo*, and thus to bring before us the same idea which is presented in the Sanscrit Ahi and Vritra. The derivation of the name Phix from the Bœotian Mount Phikion must be classed with the derivations of Apollo Lykios from the country Lycia, or of ORTYGIA, as an epithet of Artemis, from an islet off the eastern coast of Sicily.

Thus, then, like Vritra, the Sphinx is a monster who chokes up the rain-clouds and prevents them from refreshing the earth in the time of drought, and, like Vritra, she can be overcome only by the power of the sun, signified in the Theban legend by Œdipus. A few mythical phrases serve to explain the tale. The first, *Œdipus is the slayer of the Sphinx*, reproduces the struggle of Zeus against Typhon, of Apollo with the Delphian dragon; the second, *Œdipus has smitten the Sphinx*, as it sits like the storm-cloud on the brow of the hill overhanging the city, brings before us the spear of Indra when it falls on Vritra, the demon who lurks behind the masses of thunderclouds piled above the plain. In the riddle of the Sphinx we have the old saying that man cannot comprehend the language of the thunder; while in the solution of the enigma by Œdipus, we see the wisdom of Apollo which even HERMES longs in vain to acquire, and which knows the secret things of the highest heavens and the unfathomable sea. The discovery of the secret is followed by the death of the Sphinx, who precipitates herself from the cliff on which she has been seated, precisely as the smiting of Vritra is followed by torrents of rain from the clouds which he had made his hiding-place.

The form of the so-called Egyptian Sphinx is that of a winged lion with a human head and bust, always in a lying attitude, whereas the Greek Sphinx is represented in any attitude which might suit the fancy of the poet. The Egyptian figures seem to have been set up in avenues, forming approaches to the great temples. The statue disinterred by Belzoni near the Pyramids of Ghizeh has again been nearly covered with sand. It is stated by Pliny that the Sphinx represented the Nile in a state of flood, as this event occurred regularly under the signs of the Virgin and the Lion. Figures of lions have also been found with the heads of rams and hawks. The Egyptian Sphinx had no wings, and thus presents another point of difference to the monster of Aryan mythology.

Sphragistics (Gr. σφραγιστικός, from σφραγίς, *a seal*). The science of seals, their history, peculiarities, and distinctions, especially with a view to the means which they afford of ascertaining the age and genuineness of documents to which they are affixed. Ancient seals were chiefly impressed on common wax of different colours; sealing-wax came into use in the sixteenth century. This branch of diplomatics owes its origin to Heineccius, who published a work on the subject in 1709. Gercken's treatise, styled *Anmerkungen über die Siegel zum Nutzen der Diplomatik* (Augsburg 1781), will be found a useful guide.

Spiauterite. [WURTZITE.]

Spiccato (Ital. *divided*). In Music, a term indicating that every note is to have its distinct sound. When used in relation to instruments played with a bow, it is to be understood that every note is to have a bow distinct from the preceding or succeeding one.

Spices. The generic term for those aromatic or fragrant vegetable productions, pungent to the taste, which are used as flavouring ingredients in sauces and cookery. They also serve as condiments. The principal of these in common use are nutmegs, mace, allspice or pimento, ginger, cinnamon, and cloves.

Spider. [ARACHNIDÆ.]

Spike (Lat. spica, *an ear of corn*). In Botany, a form of inflorescence in which all the flowers are sessile along a common axis, as in *Plantago*.

Spikenard. The spikenard of the ancients has been, with tolerable certainty, pronounced by Dr. Royle to be the plant called *Nardostachys Jatamansi*, the root of which is highly esteemed at the present day throughout the East as a perfume and as a stimulant medicine. The plant is a native of the mountainous parts of the north of India. Some, however, refer the Spikenard to one of the fragrant Indian grasses belonging to the genus *Andropogon*, the *A. Iwaranensa* of Roxburgh.

Spiking Guns. Rendering guns unserviceable either (1) temporarily, by pushing into the vent a spring spike which can be removed when the spring is compressed by a rammer pushed down the bore from the muzzle; or (2) more permanently, by driving an iron nail hard into the vent, which must be drilled out before the gun can be used.

Spilanthes (Gr. σπίλος, *a spot*, and ἄνθος, *a flower*). A large genus of composite tropical weeds, the leaves of many of which have a singularly pungent taste, which is especially noticeable in the Pará Cress, *S. oleracea*. This plant is cultivated as a salad and potherb in tropical countries, and, like many cultivated plants, its native country is uncertain. The Japanese call the plant Hoko So.

Spinach (Ital. spinacce, from Lat. spina, *a thorn*). A well-known potherb, the *Spinacia oleracea* of botanists. The common Spinach is a

hardy annual, whose native country is unknown, though generally supposed to be Western Asia. It has been cultivated in this country for more than 300 years, and is noticed in Turner's *Herbal* of 1568 as 'an herb lately found and not much in use.' The plant has large thick succulent deep-green leaves, for the sake of which alone it is cultivated, and which are considered wholesome; when properly dressed, and thoroughly deprived of all moisture before being mashed with butter or rich gravy, they make an excellent dish, which may be eaten with any kind of meat. The seeds of one of the species are spiny, whence it is commonly called, tautologically, Prickly Spinach. It is a singular fact that the water drained from Spinach after being boiled is capable of making as good match-paper as that made by a solution of nitre.

Spinal Chord or **Spinal Marrow.** The name given in Anthropotomy to the portion of the great axis of the nervous system lodged in the vertebral column. It was originally suggested by the analogy of the part in texture, colour, and position in the neural canal, to the marrow in the long bone of the limbs. [MYELON.]

Spindle (A.-Sax. spindel). In Geometry, a solid generated by the revolution of the arc of a curve line about its chord. The solid generated by the revolution of a curve about its axis is called a *conoid*.

In Mechanics, the term *spindle* sometimes denotes the axis of a wheel or roller.

SPINDLE. [WEAVING.]

Spindle-tree. The common name for *Euonymus europæus*.

Spine. [VERTEBRÆ.]

Spines (Lat. spinæ). Branches which, being imperfectly formed, lose their power of extension, become unusually hard, and acquire a sharp point. They are very different from aculei, or prickles, which are a kind of hardened hairs. In leaves, they are processes formed either by an elongation of the woody tissue of the veins, or by a contraction of the parenchyma; in the former case, they project beyond the surface or margin of the leaf, as in the holly; in the latter case, they are the veins themselves become indurated, as in the palmated spines of *Berberis vulgaris*.

Spinel (Fr. spinelle). An anhydrous aluminate of magnesia, consisting (when pure) of 71·99 per cent. of alumina and 28·01 magnesia; but part of the magnesia is often replaced by lime and the protoxides of zinc, manganese, and iron, and the alumina sometimes by peroxide of iron.

It is of various tints of red, violet, and yellow, sometimes black, as at the copper mine, Migiandone, in the valley of Toce in Piedmont; occasionally nearly white. It occurs in octahedrons, the edges of which are occasionally replaced, and sometimes in rhombic dodecahedrons; also in macles. It is found in Wicklow in small rounded grains, in the sands of mountain streams; but the finest specimens are brought from Ceylon, Siam, Pegu, and other eastern countries. Spinel constitutes a beautiful gem, which is often sold for Oriental Ruby. The Scarlet Spinel is called *Spinel Ruby* by lapidaries; the rose-red, *Balass Ruby*; the yellow or orange-red, *Rubicelle*; the violet-coloured, *Almandine Ruby*.

Spinellane or **Spinelline.** A name given to the variety of Sphene (*Séméline*) found at Lake Laach, near Andernach, on the Rhine.

Spinelle. [SPINEL.]

Spinelle Ruby. The name given by lapidaries to the scarlet varieties of Spinel.

Spinet (Ital. spinetta). A musical stringed instrument with a key-board, &c., similar in construction to a harpsichord, from which, indeed, it little differs, except in being much smaller; but like that, it is now superseded by the pianoforte.

Spinners or **Spinnerets.** In Entomology, organs with which insects form their silk or webs. In spiders they consist of two retractile pieces issuing from anal protuberances, and giving out the threads.

Spinning. [COTTON MANUFACTURE.]

Spinning Jenny. [COTTON MANUFACTURE.]

Spinozism. This name is sometimes used to denote the ethical system of Benedict Spinoza, a Jew of Amsterdam, born in 1634. This system was called ethical, because, although founded on a speculative view of nature, it had freedom and duty for its object. From a few axioms he deduced mathematically the principle that 'there can be no substance but God: whatever is, is in God, and nothing can be conceived without God.' His system has been pronounced immoral, in so far as it 'prostrates the energies of the soul before a cold and sterile synthesis of the All, considered as a mere mechanism of causation.' This system is closely connected with the critical method by which, in the *Tractatus Theologico-Politicus*, he examined the several books of the Old Testament for the purpose of showing that any theory of biblical infallibility was untenable, and of protesting against the position which 'submitted the divine light of reason, heaven's best and noblest gift, to the dead letter of a book exposed during so many ages to all the hazards of malice, mutilation, and neglect.' With this purpose he entered into a detailed examination of the several books, the circumstances of the writers, and the occasion of their composition, and thus sought to show that all the documents illustrated the psychological conditions of their literary origin, like any other human records. He thus separated religion from theology, making the former to consist in a spirit which harmonised with this scientific method, and was prepared to accept all conclusions established as facts, without regard to consequences. This distinction led him to claim the right of free enquiry only for the religion of philosophy as distinguished from the religion based on traditionary theology. (Hallam's *Literary History*; Brucker, *History of Philo-*

sophy; Mackay, *The Tübingen School and its Antecedents*.)

Spinster. Literally, a woman who spins; but in Law the word is the common title of unmarried women.

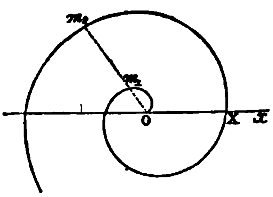
Spinthère (Gr. σπινθήρ, *a spark*). A greenish variety of Sphene, occurring crystallised in very irregular four-sided pyramids, which are obliquely truncated, in Dauphiny, adhering to crystals of Calc Spar.

Spiracles (Lat. spiraculum, *a breathing hole*). In Entomology, the breathing pores of insects are so called.

Spiræa (Lat.; Gr. σπειραία). A genus of Rosaceous plants, consisting of shrubs or perennial herbs. Among the latter is the fragrant-blossomed Meadow Sweet, *S. Ulmaria*. The essential oil of this plant has been produced artificially by the oxidisement of salicine, and has been termed *spiroylous acid*. Its chemical formula is $C_{14}H_5O_3 + HO$.

Spiral. In Geometry, the name given to a large class of curves which, in general, have the property of circulating round a point or *pole*. They receive different names according to their properties or their discoverers. Some of the principal spirals are noticed under the titles, SPIRAL OF ARCHIMEDES, HYPERBOLIC SPIRAL, LOGARITHMIC SPIRAL, PARABOLIC SPIRAL, &c. For the investigation of the properties of spirals, see Leslie's *Geometrical Analysis*; Peacock's *Examples of the Differential and Integral Calculus*; Maclaurin's *Fluxions*, &c.

Spiral of Archimedes. The curve traced by a point moving with uniform velocity along a line (radius vector) which rotates with uniform velocity around a point. Its equation is obviously $r = a\theta$; it starts at the pole o, and every two consecutive convolutions intercept a constant length $2\pi a = m_1 m_2$ upon all radii vectores. It is sometimes called the *equable spiral*, and was proposed by Conon to Archimedes, who in his treatise *On Spirals* investigates many of its properties. It is the pedal of the involute of the circle, and has for its inverse the hyperbolic spiral $r = \frac{a}{\theta}$, or reciprocal of the involute. [PEDAL.] These spirals belong to the family whose general equation is $r = a\,\theta^n$, a characteristic property of which is that the radius vector as it rotates is cut less and less obliquely by the curve; it is only after an infinite number of rotations, however, that the radius vector cuts the curve perpendicularly.



Spiral Vessels. In Vegetable Anatomy, spiral vessels are membranous tubes with conical extremities, lined in the inside by a fibre twisted spirally, and capable of unrolling with elasticity. Their function is that of the conveyance of air. They are found in almost any part of the plant except the bark; but are most abundant in leaves and flowers, and least common in the stem and root, except in the medullary sheath of the former.

Spire (Lat. spira). In Architecture, amongst the ancients, the base of a column, also the astragal or torus of the base. In modern architecture, however, the term is applied to the erection above the tower of a church, which diminishes gradually as it rises, sometimes assuming the form of a plain slender pyramid, polygonal on plan, rising from the square base formed by the tower from which it springs.

Spirifer. The name of a genus of extinct Palliobranchiate molluscs, characterised by the shell having two internal calcareous spiral appendages.

Spirit. [SOUL.]

Spirit Level. A glass tube nearly filled with spirit of wine, and hermetically sealed at both ends. The exact horizontal position of its axis is ascertained by the air bubble being at equal distances from the middle point in the length of the tube. The level is used for determining the relative heights of ground at two or more stations, and also for determining the horizontal position of any surface.

Spirit Room. A department in the hold of a ship, which serves as the vessel's wine-cellar. Its precise locality depends on the circumstances of stowage.

Spirit of Wine. [ALCOHOL; FERMENTATION.]

Spirits. Fluids containing more than half their bulk of absolute alcohol are known by this name—that in which equal parts of water and alcohol are combined being known as *proof* spirits; and the increased proportion of the latter ingredient being designated as so many degrees over proof. The word is also employed for wood alcohol, the common naphtha; and in the language of certain trades, as, for instance, the dyers, certain chemical compounds, as chloride of tin, are also called *spirits*.

Generally, however, spirits are understood to signify such alcoholic drinks as are intended for drinking. Of these there are three principal kinds: brandy, which is distilled from wine; rum, from fermented molasses; whisky and gin or geneva, from malted grain. Large quantities of spirits are distilled from potatoes, the starch of which is fermented. The flavours of spirits are derived from certain essential oils or ethers developed in the process of distillation, or gradually evolved as the spirit is kept, or, in the case of grain spirits, added as flavouring to the distilled fluid.

As the intrinsic price of spirits, owing to the heavy customs and excise duties which are levied on them, is far less than the selling price, spirits are stored in bond, even when manufactured at home, the duty being payable only when the fluids are taken out in parcels for consumption.

The following are the prices of proof spirits (in bond) by the gallon, for four years:—

	1861	1862	1863	1864
	s. d.	s. d.	s. d.	s. d.
Rum, West Indian	2 6$\frac{3}{8}$	2 2	1 11$\frac{3}{4}$	2 3$\frac{1}{4}$
Brandy	9 1	9 1	7 6$\frac{1}{4}$	6 2$\frac{5}{8}$

The excise duty paid on British spirits for the five years ending with 1865, amounts, on an average, to 9,500,000*l.* per annum.

Imports of Foreign Spirits for the Five Years ending 1865.

	1861	1862	1863	1864	1865
	gallons	gallons	gallons	gallons	gallons
Rum	8,114,823	7,765,099	7,194,738	5,499,872	6,898,599
Brandy	2,097,934	2,375,835	3,132,293	4,907,771	3,122,576
Other foreign and colonial spirits .	666,245	417,481	858,999	1,328,802	1,700,407
Total	10,879,002	10,558,415	11,186,030	11,736,445	11,729,582

The importations show little aggregate variation, the increase of foreign spirits being due to the equalisation of duties.

Spirit-rapping. [CLAIRVOYANCE.]

Spirito, Spiritoso (Ital. *spirit, with spirit*). In Music, denotes, when affixed to a movement, that is to be performed in a spirited manner.

Spiritualism. That system according to which all that is real is spirit, soul, or self; that which is called the external world being regarded as either a succession of notions impressed on the mind by the Deity, or else the mere educt of the mind itself. The first is the spiritualism of Berkeley; the second, which may be called pure egoism, is that of Fichte. [MATERIALISM.]

Spiritus Asper (Lat.). In Grammar, the rough breathing, marked thus ʽ, placed before Greek words beginning with a vowel, which should be pronounced like words beginning with *h* in English. It is also placed before all words beginning with the letter ρ.

Spiritus Lenis (Lat.). In Grammar, the soft breathing, marked thus ʼ, placed before all Greek words beginning with a vowel, which have not the rough breathing. It thus denotes merely the absence of the spiritus asper.

Spirketting. That part of the inner planking of a ship which lies between the ports and the next lower water-way. It serves to keep the water-way fixed, which, in its turn, holding down the beam ends, gives solidity to the entire structure.

Spirous Acid. [SALICYLOUS ACID.]

Spirulidæ. The name of a family of Dibranchiate Cephalopods, of which the genus *Spirula* is the type. They are characterised chiefly by having a spiral discoid chambered shell developed in the substance of the mantle, instead of a calcareous or horny plate.

Spittle. [SALIVA.]

Spiza (Gr.). The Spiza of Aristotle is supposed to be the same as the Chaffinch, or *Fringilla cœlebs*, of Linnæus. The chaffinch is permanent in the South of Europe, and a regular bird of passage in the northern countries. Its notes are susceptible of a greater range of modulation than in the other members of the genus. The colours of the male are far more brilliant than those of the female.

Splanchnology (Gr. σπλάγχνον, *an entrail*, and λόγος). The doctrine of the viscera.

Splanchnoskeleton (Gr. σπλάγχνον, and σκελετόν, sc. σῶμα, *a dried body* or *skeleton*). Those bones which are connected with the sense organs and viscera, e. g. the heart-bone in the bullock and some other large quadrupeds.

Splayed (a corruption of *displayed*). In Architecture, a term used to express an angle cut off, or oblique on plan.

Spleen (Gr. σπλήν). A spongy viscus, of an oval form, the use of which is unknown. In the human subject it is placed in the left hypochondrium, between the eleventh and twelfth false ribs. The term *spleen* is also used for a species of hypochondriasis to which the English are said to be particularly open.

Splenitis (Gr.). Inflammation of the spleen.

Splenius. A flat muscle, situated between the back of the ear and the lower and posterior part of the neck.

Splent or Splint Coal. A hard laminated kind of coal, less bituminous than caking coal, and intermediate between Cannel and common pit-coal. It burns free and open, without caking, and furnishes a good house-coal. Splint coal is produced by the Glasgow coal-field, as well as by those of Shropshire, Warwickshire, Derbyshire, and Nottinghamshire, and constitutes the bulk of the coal from North and South Staffordshire.

Splicing (Ger. splessen, *to split*). Joining the two ends of a rope, or uniting one end to any intermediate part by interweaving the strands. An *eye splice* forms an eye or circle at the end of a rope. A *short splice* is the joining of two ends not intended to pass through a block. A *long splice* is used to unite two ends which have to pass through a block. It is formed by untwisting the two ends, and interweaving the strands of one in the alternate strands of the other. The strands must be hauled well through, and beaten with a marline spike to render them firm.

In Naval language, the phrase, *to splice*

the main brace, denotes an extra allowance of spirits in cases of cold or wet.

Splint (connected, like *splinter*, with *split*). A piece of wood or pasteboard, so shaped as to support a broken or debilitated limb.

Splintery. That fracture of minerals which is nearly even, but exhibits small splinters or scales thicker at one extremity than the other, and adhering by their thicker ends to the broken surface.

Spodumene (Gr. σποδόω, *to burn to ashes*). A silicate of alumina and lithia, with part of the lithia replaced by soda. It is found in crystallised and laminated masses, hard, brittle, translucent, and of various shades of green or grey. It was first discovered at Utö, in Sweden. Before the blowpipe, it exfoliates into little scales of an ash colour; hence its name. It is also found in granite, at Killiney, co. Dublin, in long bent prisms of a greenish-grey colour. It is also called *Triphane*.

Spoliation, Writ of. In English Law, this writ is obtained in the ecclesiastical courts for the fruits of a benefice. The suit founded on this writ lies for one incumbent against another, where they both claim by one patron, and the right of patronage is not in question.

Spondee (Gr. σπονδή, *a libation*). In Greek and Latin Poetry, the name of a foot consisting of two long syllables. It was so called because, from its slow movement, it was ordinarily employed in the hymns sung in honour of the gods during the offering up of a sacrifice.

Spondaic verse is an hexameter line, in which the two last feet are spondees, instead of the usual termination, a dactyl and a spondee; but in these the fourth foot is always dactylic.

Spondias (Gr. *a kind of wild plum*). A genus of *Anacardiaceæ*, the species of which are natives of the tropics of both hemispheres. The fruits of some of them are edible. Thus, in Brazil and the West Indies, *S. lutea*, *S. Mombin*, *S. tuberosa*, &c., yield fruits eaten under the name of *Hog Plum*, the taste of which is said to be peculiar, and not agreeable to persons unused to them. These fruits are chiefly used to fatten swine. *S. dulcis*, a native of the Society Isles, yields a fruit compared in flavour to that of the Pine-apple. *S. mangifera* yields a yellowish-green fruit, which is eaten in India, and is used as a pickle in the unripe state.

Some of the species are employed medicinally. Thus, the bark, leaves, and wood of *S. mangifera* are used in various complaints in India. An insipid gum also exudes from the bark of this tree. *S. Mombin* has astringent leaves, while its fruits are laxative, and its seeds are said to be poisonous. The bark of *S. venulosa* has aromatic astringent properties. *S. tuberosa* is also employed in fevers; the fruit is the part used. *S. Birrea* affords to the natives of Abyssinia an edible kernel, while its fruits are employed in Senegal in the preparation of an alcoholic drink.

Spondylus (Lat. from Gr. σπόνδυλος, or σφόνδυλος). The name of a Linnæan genus of the Vermes Testacea, comprehending the spring oysters; characterised by having a strong tooth on each side of the depression lodging the elastic ligament of the hinge of the shell. The genus is included in the Ostracean family of the Acephalous Testacea by Cuvier, and has been subdivided by Lamarck into the genera *Spondylus* proper and *Plicatula*. Some of the species of *Spondylus*, as the water-clam (*Sp. varius*), form a series of chambers by secreting successive layers of nacreous shell at a distance from each other, the last chamber containing a quantity of fluid, which escapes by very slow evaporation through the pores of the calcareous shell.

Sponge (Gr. σπόγγος, akin to Lat. fungus, Fr. éponge). In Artillery, a wooden staff, the head of which is covered with sheepskin, and adapted to the form of the chamber or end of the bore of the piece of ordnance for which it is intended. It is used to free the bore from any impurities left by the discharge, or any lighted fragments of the cartridge.

SPONGE. In Commerce, sponge is a cellular elastic albuminous tissue, covered in the living state with a kind of semifluid sarcode. After death, this substance drips or drains away, and leaves merely the sustaining tissue, called *sponge*; formed by the combination of a multitude of small canals, capable of receiving water in their interior, and of becoming thereby distended. The sponges of this kind, called *keratose* or *horny*, occur attached to stones at the bottom of the sea, and abound particularly upon the shores of the islands in the Grecian Archipelago. Sponges afford on distillation a considerable quantity of ammonia; and contain a substance called *fibroine*, which is closely analogous in constitution to silk.

The sponges of commerce are usually prepared before they come to the market, by being beaten and soaked in dilute hydrochloric acid (36 water + 1 acid) with a view to cleanse them, and to dissolve adherent portions of carbonate of lime; but the use of any mineral acid as a solvent is said to deteriorate the quality of the article. The varieties of sponge are very numerous, not less than 250 having been reckoned, but of these only three kinds are met with in commerce, two being derived from Turkey, the third from the West Indies. Turkey sponge is distinguished as *toilette*, the form of which is cup-shaped, the edges of the tubes being fringed with long filaments; or as *honeycomb*, a coarser and more solid variety. The chief mart for Turkey sponge is Smyrna, and quantities varying from 500,000 lbs. to little more than 100,000 lbs. are annually imported from this city. West India sponge is almost valueless, and is imported, it seems, merely to hawk about in the streets and deceive unwary buyers by its apparent cheapness.

Sponge is sold by weight, and many fraudulent devices are adopted among the dealers of the Levant to increase its weight, such, for instance, as laying the fresh sponge on the shore, so that the ripple of the water may fill the pores with fine sand. (*Com. Dict.*)

Sponge. In Natural History, the name of a class of organisms (*Porifera*) which have not acquired the distinctive characters of plants or animals, but consist of sarcode or *gelatinous flesh*, composed of an aggregate of amœbiform bodies, connected and supported, in most of the species, by a spicular framework, which may be silicious, calcareous, or albuminous. The mass, which is commonly amorphous, is traversed by canals, of which those that terminate in the superficial *pores* are *incurrent*, and those that terminate in larger orifices or *oscula* are *excurrent*. The main sign of vitality is the course of currents of water entering by the *pores*, and escaping by the *oscula*. The incurrent streams are nutrient, the excurrent carry out the waste particles and the spores. The latter are ciliate and locomotive, as in some algæ. The movement of the currents is due to ciliary action. The most definitely shaped and beautiful sponges are those of the genus *Euplectella*; the most useful are the *horny* or *keratose* kinds, represented by the *Spongia officinalis* of commerce. Sponges belong to the sub-kingdom *Protozoa*. [Acrita; Amorphozoa.]

Sponge Tent. This material is formed by dipping sponge into hot melted wax plaster, and pressing it till cold between two iron plates: it is then cut into pieces, and used for dilating wounds.

Spongiole. In Botany, the lax cellular tissue and mucus situated at the extremities of roots, having the property of absorbing fluid like a sponge; whence the name.

Sponsions (Lat. sponsio, *a bond*). In International Law, acts and engagements made on behalf of states by agents not specially authorised, or exceeding the limits of the authority under which they purport to be made, are so called by writers on this branch of jurisprudence. Such conventions must be confirmed by express or tacit ratification. The latter is implied from the fact of acting under it as if bound by its stipulations; but mere silence is not, in general, held equivalent to ratification. Such are the official acts of admirals and generals suspending or limiting hostilities, capitulations of surrender, cartels of exchange, &c. (Grotius, *De Jure Bel. et Pac.* lib. iii.; Vattel, liv. ii.; Wheaton *On International Law*, vol. i. p. 291.)

Sponsors (Lat. sponsor, *a surety*). In the Roman Catholic, Greek, Lutheran, and Calvinistic Churches on the Continent, and in the Church of England, the name given to the persons who at the baptism of infants make a profession of the Christian faith in their name, and guarantee their religious education. (Neander's *Church History*, vol. i. part ii.) In the Presbyterian Church, baptism is administered without sponsors.

Spontaneous Axis. Under certain circumstances the motion of a perfectly free body, under the action of instantaneous forces, resolves itself, at the first instant, to a simple rotation about an axis unaccompanied by any motion of translation. When this is the case, the axis is termed a *spontaneous* one. Thus the effect upon a body of a blow whose line of action is parallel to a central principal axis is to cause rotation, for an instant, around a spontaneous axis. (Poinsot 'On Percussion,' in Liouville's *Journal*, 1857.) Euler, in his *Theoria Motus*, 1790; Lagrange, in his *Mécanique Analytique*, Paris 1853; and Delaunay, in Liouville's *Journal*, vol. v., have also written on this subject.

Spontaneous Generation. The notion that corruption is the source of life was, among the ancients, almost universal, and it is a common popular opinion even in the present day. In the scientific world, indeed, the opinion that organised beings can arise without pre-existent germs, has been all but exploded. It has, however, of late been revived; and if the facts brought forward could be implicitly depended upon, the doctrine would certainly be less doubtful than it has of late been considered.

Wherever due attention has been paid, observes Mr. Berkeley, to prevent the possibility of access of atmospheric air, no vegetation has ever appeared, provided proper precautions have been taken to place all possibly pre-existent germs in such a condition that their reproductive powers must be destroyed. If the residue of rain or snow-flakes, or the dust of trade winds, is carefully examined, numerous animal and vegetable productions may always be detected; and the lower forms of either kingdom are propagated with such extreme rapidity, that the swarming of animals or vegetables in *infusions* seems almost magical. Some of these will bear a heat equal or even much superior to that of boiling water for some time without losing their vitality; therefore the simple boiling of water is not sufficient, even if, while it passes through a furnace, care be taken to exclude the outward air or to prevent its containing reproductive germs. Concentrated sulphuric acid has sometimes been used for the same purpose, but this plan is subject to error, as, whatever may be the case with germs which may be present on the outside of a bubble passing through the acid, it does not follow that those in the middle of the bubble should be killed. Experiments, however, have been carried on by M. Pouchet, which appear to exclude all chance of the accidental transmission of germs through the sulphuric acid; but these experiments have been met with counter results of experiments by M. Pasteur. In the present state of the controversy, which is as yet undecided, no general conclusion can be drawn, and more facts are required. Nevertheless, it is apparent that a much larger number of scientific men are now disposed to look favourably on the doctrine of heterogenesis than twenty years ago. The synthesis of *inorganic* and *organic* matter seems within the limits of possibility. (Lindley and Moore, *Treasury of Botany*.) [Species.]

Spool (Ger. spule). A piece of cane or reed, or a hollow cylinder of wood with a ridge

at each end, used by weavers for winding their yarn.

Spoondrift. The light spray blown off the waves in a violent wind.

Sporadic (Gr. σποραδικός, *scattered*). A term applied to such diseases as attack a few persons only at any time or season.

Sporangia (Gr. σπορά, *a seed*, and ἀγγεῖον, *a vessel*). This word is used in cryptogamic Botany, to denote the cases in which the spores are formed. In ferns it is applied to the little cysts with their elastic ring; in pseudo-ferns, to the organs immediately containing the spores, whether naked or contained in a common receptacle; in mosses, to the urn-shaped bodies which are often called *capsules* and *thecæ*. Amongst algæ, lichens, and fungi, it is seldom used in a general sense. In the latter it is sometimes applied to asci when large and pear-shaped as in truffles, to the spore-bearing vesicles of moulds, or to the lens-shaped bodies contained in the receptacles of plants like *Nidularia*, though they are certainly not of the same nature as the organs just mentioned. When the case is so small as to become microscopic, it is sometimes called *sporangiolum*.

Spore (Gr. σπορά). The reproductive bodies of cryptogams. These bodies do not contain an embryo, but consist merely of one or more cells variously combined together; hence, they are called *spores* to distinguish them from true seeds. Amongst *Fungi*, the name is restricted to those reproductive bodies which are produced either singly or in little chains at the tips of the fruit-bearing threads. In many cases, however, these bodies are generated within cells or asci, and they are then for distinction's sake termed *sporidia*. It is, however, desirable that the word *spore* should be used in the more general sense, as opposed to *seed*, the grand distinction between cryptogams and phænogams consisting in the different nature of their mode of reproduction.

The spores of acrogens are produced for the most part in mother-cells four together, after the manner of pollen-grains—often retaining their original form, so that when mature they have one spherical and three plain sides. In a few genera, however, there is only a single spore in each sporangium. In *Algæ* the spores are sometimes nothing more than the transformed joints of certain threads; sometimes they appear to be formed from the contents of a cell, as they are in the ascigerous *Fungi*; sometimes they are endowed with active motion like animals, and are then called Zoospores. In Lichens they are of the same nature as the sporidia of *Fungi*.

Spores or sporules germinate either by elongation of some particular part, and subsequent cell-division, or by cell-division without any protrusion of a thread or membranous expansion. In *Myxogastres* they germinate sometimes after the fashion of other *Fungi*, but sometimes the outer case is ruptured, and a body appears with the attributes of some of the lower *Infusoria*, which, apparently without any cellular division, produces the semi-gelatinous mycelium peculiar to those *Fungi*.

Sporidia (a word coined from Gr. σπορά, and εἶδος, *form*). A term used in describing the spores of *Fungi* and Lichens when they are contained in asci. Sporidia, like spores, may consist of one or more cells, and these may be covered with a distinctly organised cuticle. They have frequently a thick gelatinous coat, which is usually absorbed as the contents of the cells become fully organised. They germinate by the protrusion of the inner membrane, the outer being ruptured or perforated, or in some cases by the elongation of both. In compound sporidia a distinct germinating thread is often produced by each cell. Sporidia are by no means constant in size and form. Great differences of dimensions and outline may exist in the same ascus. They have sometimes a very different outline when seen from the back or side; and in some cases, like the spores of so many Agarics, they are hollowed out on one side like a fragment of a bombshell. In many cases the ascus in which they were generated is absorbed, so that they appear naked; and it is probable that occasionally they undergo further developement when free, as is certainly the case with that of some spores of *Fungi*. These reproductive bodies are sometimes called *sporidiola*.

Sportum, Sportula (Lat.). In Roman Antiquities, a dole. It was an ancient usage in Rome for rich men to distribute victuals on certain occasions among their poor clients, each of whom attended for the purpose with a wicker basket (sportum). Afterwards this dole was generally commuted for money; and the sum thus distributed, about 100 quadrantes, or eighteen pence English, was called *sportula*.

Sporules (Gr. σπορά). The reproductive bodies of Asexual or Cryptogamic plants; differing from seeds in not being generated by impregnation, and in having no definite and predetermined points of growth, but springing forth into young plants from any part of their surface. [Spores.]

Spots on the Sun. [Sun.]

Spottiswoode Press. [Printing Machine.]

Spring (a Teutonic word). In Astronomy, one of the four seasons of the year. For the northern hemisphere, the spring season begins when the sun enters Aries, the first of the northern signs, or about March 21, and ends at the time of the summer solstice. [Seasons.]

Spring. In Mechanics, a piece of mechanism, formed of tempered steel or some other elastic substance, applied mostly for the purposes of producing resistance, or of preventing a shock from the collision of hard bodies, or of giving motion to mechanism by its effort to unbend itself. For the law of the force exerted by a spring, see Elastic Curve.

Spring. In Naval language, a rope or hawser passed from the stern of a ship and made fast to the cable or anchor from the bow

by which she is riding. The object is to vary at will the direction in which she rides, an object of importance when the broadside has to be brought to bear on any given point.

Spring Beam. In the paddle-box of a steam vessel the spring beam is a strong timber parallel to the ship's side, and forming at once the base of the paddle-box and the seat of the plummer-block in which the end of the paddle shaft revolves. It is held in position by the paddle beams projecting beyond the vessel's side. In many modern forms of paddle-box the spring beam is dispensed with, the paddle shaft working in a chock in the side.

Spring Tides. The tides at the times of the new and full moon. At these times the sun and moon are in a straight line with the earth, and their joint effect in raising the waters of the ocean is a maximum, and the tides are consequently the highest. [Tides.]

Springs. Outflows of water or other liquid from the earth. They occur in all parts of the world, in valleys and on hill tops, on land and under water, within caverns, at hill sides, at all levels, and both naturally and after artificial boring through the superficial strata. All water springs are connected ultimately with the rainfall from the clouds, a complete circulation being thus kept up. Oil Springs are connected generally with large deposits of organic matter, either animal or vegetable. Mineral Springs and Thermal Springs consist of water that has passed through the deeper and heated portions of the earth's crust. Springs occur naturally in gravel; at hill sides, where they issue from the edges of strata; or at faults in strata. They are especially common in stratified and limestone districts, but some are found even in granite. [Fountain.]

Springs, Artesian. Vertical perforations of the exterior crust of the earth, of small diameter, and frequently of great depth, through which subterraneous water rises to the surface, often forming abundant and elevated jets. [Artesian Well.] The oldest Artesian well known to exist in France is in the ancient convent of the Chartreux, at Lillers, in Artois. It is said to have been made in 1126. The inhabitants of Egypt and of the great desert of Sahara appear to have been long acquainted with this mode of obtaining water, and the Chinese are said to have practised it for thousands of years.

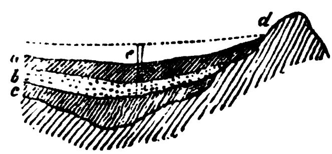
Various conjectures have been made as to the source of the water which comes from the Artesian wells. The simplest and most natural explanation is, that the water is supplied by the rain which falls on the surface at a higher elevation, and which penetrates through the pores and fissures of the ground till it meets with some impermeable stratum, or is collected in subterranean reservoirs. It has been objected that springs are sometimes situated on or near the summits of mountains, which could not be supplied in this way; but on an attentive examination of all the circumstances, i.e. on measuring accurately the extent of surface at a greater elevation than the spring, and comparing it with the quantity of rain that falls annually in the same climate, it has been found, in every instance, that the aqueous deposition from the atmosphere greatly exceeds the supply from the spring. It is computed that not more than a third part of the rain which falls in the valley of the Seine is conveyed to the sea by the river; the remaining two-thirds support vegetation, supply fountains and springs, or are returned to the atmosphere by evaporation. The immense bodies of water which some continental rivers roll towards the ocean are but a small part of the rain which falls in the surrounding countries.

Assuming, then, that the subterraneous water is supplied from atmospherical deposition, it remains to be explained how it arrives at the situation it occupies in the interior of the earth, and by what forces it is raised from great depths to the surface.

All persons who have paid the slightest attention to geology are aware that in stratified countries different beds of rocks are superposed on one another, and ranged in a certain order. The strata sometimes follow a horizontal direction for a considerable extent of country; at other places they are inclined to the horizon, appearing to have been thrust up by the action of a powerful force acting from beneath the surface. In such cases the edges of the strata are often exposed, especially on the summits and flanks of hills, to the action of the atmosphere. Between the strata are frequently found beds of permeable sand, through which water, coming in contact with them, must necessarily pass, first through the inclined part by virtue of its specific gravity, and then in the horizontal branches by virtue of the pressure of the water remaining in the elevated portions of the strata. In such manner the water insinuates itself between the different strata; and hence we may expect that as many distinct sources of subterraneous water will be met with in penetrating perpendicularly through the surface, as there are distinct layers of a permeable nature reposing on impermeable strata. This anticipation is confirmed by experience. M. Arago mentions, that, in digging for coal near St. Nicholas d'Aliermont, a short distance from Dieppe, seven distinct and copious sources of water were found, the respective depths of which were: 1st, between 80 and 100 feet; 2nd, 328 feet; 3rd, from 570 to 590 feet; 4th, from 690 to 710 feet; 5th, 820 feet; 6th, 940 feet; 7th, 1,090 feet; and the occasional force of each source was very great. Similar occurrences are frequent in the neighbourhood of London, and are familiar to all miners. But it is not enough that the structure of the country be such that water can percolate between the different strata: the phenomena of Artesian fountains could not be explained without supposing it to be collected in large quantities, and forming subterraneous reservoirs of immense extent. That such reservoirs exist, no doubt can be entertained. The celebrated fountain

of Vaucluse sends forth at all times a stream of water sufficient to form a considerable river. Even in the driest seasons, when the water is least plentiful, it yields 4,780 cubic feet per minute. After great rains, its product is thrice as great. The mean quantity emitted is 9,360 cubic feet per minute, or about 5,030 millions of cubic feet in a year. Many other examples of the same kind might be cited, showing that water must not only be collected in subterraneous cavities in immense quantities, but that it also passes freely from one place to another. In fact, the disposition of the rocks in strata permits the water to be collected under the surface and to be conveyed without waste, as if in close pipes.

According to the view which has now been taken of the manner in which subterraneous water is collected, its elevation to the surface through a natural fissure or artificial perforation is a simple result of hydrostatic pressure. Generally speaking, the edges of the strata are exposed only on the acclivities of hills, or in elevated places, where, consequently, the rain water can be received under beds of



impermeable materials. Conceive two strata of clay or rocks, as *a* and *b*, having a bed of sand or other matter permeable to water interposed, and suppose that *d* is the place where the edges of the strata crop out, or where a fissure allows a free entrance of the water to the permeable stratum. The water at first descends through the effect of gravity; it then passes along towards *b* in consequence of the pressure exercised by the superior part of the column near *d*. Now, suppose a perforation to be made at *e*, and continued till it reaches through the stratum *a*, the water will naturally continue to rise till it gains the same altitude as *d*, or at least till it reaches the surface if below that altitude. The water, in fact, between the two impermeable strata is in the same circumstances as in an artificial pipe; and if the surface of the ground at *e* is considerably lower than *d*, the ascensional force may be sufficient to cause a considerable jet.

Some Artesian fountains (for example, that at Lillers, in Artois) are situated in the middle of immense plains, where not the most insignificant hill is to be seen on any side. In such cases, it may be asked where we are to look for those hydrostatic columns whose pressure causes the rise of the subterraneous water to the level of the lowest points. The answer is obvious: we must suppose them placed beyond the limits of view; at the distance of 50, 100, or 200 miles, or even at a greater distance. The necessity of supposing the existence of a subterraneous liquid column of two or three hundred miles in extent cannot appear a serious objection, when it is considered that the same geological structure has been found to prevail sometimes over even a much greater extent of country. An interesting paper on this subject is given by Arago, in the *Annuaire du Bureau des Longitudes* for 1835.

Numerous works of this kind have been executed of late years. One of the most remarkable of them is that of Grenelle, a suburb at the south-west of Paris, where there was formerly a great scarcity of water. The strata which were penetrated were: 1. The tertiary strata above the chalk; 2. Chalk; 3. Greensand and clay; 4. Oolite or Jura limestone. The sheet of water flows in a stratum of gravel under the limestone. On account of the great depth of the boring, the work was attended with much difficulty, and retarded by various accidents. At length, in February, 1841, after eight years of exertion, the engineer (M. Mulot) had the satisfaction of seeing the water he was in search of burst forth from a depth of about 600 English yards, and the jet no less than 4,000,000 litres, or in round numbers 880,000 imperial gallons, in the 24 hours. The temperature is 81° of Fahrenheit, corresponding to an increase of 1° for each 20·4 yards of descent. The bore is protected by a metal tube, divided into four unequal lengths, and successively decreasing in diameter. The dimensions are as follow: From the surface of the ground to the commencement of the first tube, 2·5 yards; length of the first tube, 165 yards; of second tube, 227 yards; of third, 72 yards; of fourth, 124 yards; from extremity of last tube to bottom of bore, 7·5 yards; total, 598 yards. The diameter of the first or highest tube is about a foot, and of the lowest about six inches, English. The expense was about 12,000*l.* sterling. For a description of the boring apparatus, and methods of conducting such works usually followed in this country, see Ure's *Dictionary of Arts, Manufactures, and Mines*; and for details respecting some Artesian wells in England, the *Reports of the British Association.*

Springs, Intermittent. In many parts of the world there are springs which sometimes issue freely and are sometimes dry. When this occurs periodically, the springs are said to be *intermittent.*

In limestone districts, springs are due to very different causes from those that act in volcanic districts; and as there are remarkable intermittent springs in both, the explanations must succeed each other.

When large bodies of water exist in hollow spaces and clefts of rock in limestone districts, the means of escape to the surface are often tedious, obscure, and winding, and liable to be partly or entirely choked. It may thus happen that water, having reached a certain point below the surface of high ground (the channels being full), may find the readiest way of escape by means of a kind of natural pipe, which first rises a little and then descends

to a free outlet. In this case, if the delivery pipe is at a lower level than the receiving pipe, and the total rise less than thirty feet, the combination will act as a siphon, and the contents of the reservoir be rapidly drawn off when the siphon acts, and slowly or not at all while the water is rising to such a level as to cause the siphon to begin its action.

Intermittent springs in volcanic districts are very different, and involve the action of steam, probably under high pressure. The geysers of Iceland are fine specimens of such springs. [GEYSERS.] They rise in a tract covered by lava. The Great Geyser springs from a spacious basin at the summit of a mound formed of silicious incrustations deposited by the spray of its waters. In the centre of this basin is a pipe 78 feet deep, through which the water rises, flows over, and is thrown up in jets, attended by loud explosions and subterranean rumblings, and slight tremors of the ground. When these jets are most violent, they shoot to a height of 200 feet; and after playing for some time, a snorting noise is heard, which gradually becomes as loud as thunder, and steam rushes forth with prodigious violence. This deafening roar lasts for a variable time, and the eruption terminates, coming on again after a variable interval of rest.

A satisfactory explanation of these remarkable springs has been offered by Professor R. Bunsen, in his important memoir on pseudo-volcanic phenomena. He refers to the funnel of the geyser, as the main seat of the mechanical force, by which the mass of water is thrown up and converted into boiling foam. The correctness of this he proved by sinking marked stones to different depths; only those suspended near the surface were thrown to a great height. In the lower part of the funnel and in the reservoir below the water, the heat is far above the boiling point. At and near the surface cooling goes on very rapidly. After an eruption, the water falls back in the basin, and, as it rises again, the temperature goes on increasing up to a certain height in the funnel, which is half the height between the surface and the reservoir. When a fresh eruption is about to commence, the temperature approaches to that of the boiling point of the water under the pressure of the column above. At this time a very slight impulse suffices to bring a large portion of the column into a state of ebullition; and the mechanical force thus developed is more than sufficient to raise the huge mass of the water to the great elevation already described. By actual calculation, Professor Bunsen proves that the column of water is fully capable of performing the eruption by the force thus generated. Other intermittent thermal springs are known in Iceland, and of these the Little Geyser is an example. They are due probably to the existence of a subterranean caldron or focus of vapour, and the eruption is caused by the pressure of steam on the roof of this cavern or caldron. This pressure is small immediately after an eruption, but as water pours in and the heat continues, there is no escape, and at length the force becomes sufficient to throw the whole column into the air. The intervals between these eruptions are not very regular.

Springs, Mineral. In many parts of the world, water issues from the earth loaded with mineral matter in solution. The carbonates of lime, magnesia, and soda; sulphates of lime, magnesia, potash, and soda; muriates and chlorides of soda, magnesia, and lime; iron and silica, are the minerals chiefly contained. Carbonic acid gas, oxygen, nitrogen, and sulphuretted hydrogen gases, are also contained sometimes in very large quantities.

Mineral springs often pour forth from the ground, in parts of the earth where there are no volcanic rocks, or any appearance of recent volcanic action. They are, however, usually associated in some way with mechanical disruption of rocks. Thus, the springs at Buxton are near great faults in the carboniferous limestone, and those at Leuk in Switzerland are amongst the High Alps. Many other examples might easily be given. Central France (Auvergne) and the French side of the Pyrenees are especially remarkable for the number of their mineral springs, the volume of the water, and its mineral contents.

Occasionally large quantities of naphtha, or other bituminous fluid, pour out of the earth as springs. These have lately become so important as to require notice in a separate article.

Springs, Naphtha, Oil, and Petroleum. Jets of water containing a large admixture of petroleum and the various minerals allied, such as bitumen, naphtha, and pitch, have long been known, and localities in which fluid bitumen oozes out in large quantities from under water are also known. In one locality on the river Irawadi, there are said to be upwards of 500 such wells, yielding annually half a million of hogsheads of mineral oil; but oil wells such as those that have recently attracted attention in North America are new and remarkable phenomena. The first notices of the existence of oil springs, in North America, in large quantity, appeared about the end of 1858, and two years subsequently 50,000 gallons of valuable produce of this kind were raised daily on the western borders of New York State only. This quantity was obtained from wells sunk from 70 to 500 feet, and the oil was pumped. At the end of 1859 in the state of Pennsylvania, and in the middle of 1860 in Ohio, other oil-yielding districts were discovered, and subsequently Canada, both Upper and Lower, Kentucky, Virginia, Tennessee, Arkansas, Texas, New Mexico, and California, have all been found prolific. Cuba has recently been added to the list of localities. The oil-yielding district reaches from the 65th to the 128th degrees of west longitude from Greenwich, and from near the equator to the 60th degree of north latitude. The oil is derived from Silurian, Devonian, and carboniferous rocks.

The geological position of these oils seems not to be very strictly defined, but it is observed that the main deposit of oil is generally underlaid by tough clay. A violent outburst of carburetted hydrogen gas usually occurs when the oil is reached by boring, and this is followed by a mixture of oil and gas, and afterwards of oil alone, which is sometimes thrown to a height of 100 feet in the air. At the outset, some wells have yielded 4,000 gallons of oil in 24 hours, from a four-inch pipe.

The oils are sometimes clear and transparent, but more usually of a dark brown colour. They are very inflammable, and many accidents have occurred in their use, both at their first issue from the earth and subsequently. These oils are of the nature of naphtha. They generally require distilling, and by slow distillation yield a good lubricating oil, as well as a burning oil and a valuable residuum of paraffine for candles. Benzole is also obtained from them.

At the beginning of the present year (1866), upwards of 50,000 gallons per day were being raised, a great part of which was exported, chiefly to England.

Springs, Thermal. Many springs of hot water rise out of the earth in different parts of the world, besides the remarkable intermittent springs of Iceland. [Geysers; Springs, Intermittent.] The name *thermal spring* is applied only to those cases in which the temperature of the water, as it reaches the earth's surface, is uniform throughout the year, and higher than the mean annual temperature of the air at that point. The following are some of the most remarkable hot springs. At Buxton in Derbyshire, the springs throw out 13,500 cubic feet per day of 24 hours, at a temperature of 82°. At Bath, more than double the quantity, at 115°. At Plombières, in France, the quantity is smaller, but the temperature 147°. At Vernet, in the Pyrenees, the enormous quantity of two and a half millions of cubic feet issue at a temperature of 132°. At Wiesbaden the temperature is 158°; at Carlsbad 167°; at Cantal, in France, as much as 174°; and in the north-west of Spain 192°. Hot springs are known in various parts of Italy, in Portugal, in Greece, Turkey, and the Balkan, in various parts of Asia and Africa, and in both North and South America.

The water of hot springs always contains a certain proportion of solid ingredients held in solution, and generally some gas. The former usually consist of muriates, chlorides, carbonates, and sulphates of lime, soda, and magnesia, but include also iron and silica. Manganese, cobalt, nickel, tin, titanium, copper, lead, silver, and gold have all been detected in springs. As much as 170 grains of solid ingredients are sometimes held in each pint of water. The gases in thermal springs are chiefly carbonic acid, sulphuretted hydrogen, nitrogen, and oxygen. The larger quantities of carbonic acid are of course present in cold, not in hot water. Thermal springs are almost universally valued for their healing powers.

Springing. In Architecture, the lower part of an arch, or that part from which it rises.

Sprit, Spritsail (Dutch spriet, Old Eng. sprit, *to sprout*). A spar or pole. The word was once so used generically. It survives in several terms, notably in *bowsprit*, which is a spar sprouting from the bow. When the word is employed singly, it means a diagonal spar for supporting a quadrilateral fore-and-aft sail, the sprit's heel being against the mast, and its head maintaining the upper corner of the sail farthest from the mast. The spritsail, in particular, was a square sail borne under the bowsprit on the dolphin-striker. It is now obsolete. In very ancient ships there was a sprit-topsail on a mast rising from the outer end of the bowsprit.

Sprocket Wheel. On Shipboard, the sprocket wheel in a capstan is a wheel, armed with pointed studs, round which the chain-cable passes. The studs afford a firmer bite on the cable.

Spruce Beer. A liquor, made of treacle or molasses, and tinctured with the essence of spruce, well boiled in water and fermented.

Spruce Fir. The common name for the trees of the *Abies* family, and specially applied to *A. excelsa*.

Spruce Ochre or **Ocre de Rue.** A dark-coloured yellow ochre, similar to Roman ochre. It is much employed, and affords useful and permanent tints.

Spun Yarn. [Rope.]

Spunk (akin to *fungus* and *sponge*). *Polyporus* (formerly *Boletus*) *igniarius*, a species of fungus, called also Touchwood. The plant, when cut into thin slices and beaten till soft, has been used as a styptic to check hæmorrhage; it is also used, when soaked in a solution of nitre, for kindling matches and tobacco, under the name of Amadou or *German tinder*.

Spurge (Fr. épurge, Ital. spurgo). The common name for the plants of the Euphorbia genus. The Spurge Olive is *Daphne Mezereum*, a deciduous shrub, all parts of which, but especially the fruit and the bark, are very acrid and poisonous; it is used as a sudorific and alterative in medicine, and is sometimes applied externally as an irritant. [Daphne.]

Spurs (A.-Sax. spur). Projections carried out from the banks of rivers to deflect the current and protect the banks; they may be formed either of masonry, carpentry, or brushwood, according to circumstances. They are much employed in defending the banks of the Rhine, the Po, the Danube, the Elbe, &c.; but the French engineers appear to prefer the continuous system of defence afforded by walls, or *pierrés*.

Squad (Fr. escouade). A Military term for a small subdivision of men either for purposes of drill or interior economy.

Squadron (Fr. escadron, Ital. squadra, from Lat. quadratus, *squared*). In the Army, a body of cavalry consisting of two troops. It is the unit of cavalry tactics.

SQUADRON. In Naval matters, a section of a fleet, forming the command of a flag-officer.

Squall (Swed. squal). The Sea term for a gust of wind, or for a short temporary increase in the force of the wind.

Squalus (Lat.). In Ichthyology, the Linnæan generic designation of the shark tribe.

Squama (Lat. *a scale*). In Botany, the bracteæ of an amentum; also used occasionally for any kind of bracted or rudimentary leaf which has a scaly appearance.

Squammipennes (Lat. squama, *a scale*; penna, *a fin*). The name of a family of Acanthopterygious fishes, comprising those which have the dorsal and anal fins covered with scales.

Squameous (Lat. squamosus, *scaly*). In Zoology, when a surface is covered with small scales.

Square (Welsh cwâr, Fr. carré, Lat. quadratus). In Geometry, a four-sided rectilineal figure, of which all the angles are right angles, and all the sides equal.

SQUARE. A Military formation of troops. A *solid square* is formed to resist cavalry, and the men all face outwards. A *hollow square* is formed to hear orders read, &c., and the troops face inwards.

SQUARE. In Naval language, this term is applied to the yards, and implies that they are at right angles to the masts. *Square-rigged* means that the rig includes yards which can be set square. *Square sail* is a quadrilateral sail never borne as a fore-and-aft sail.

Square Measures. The relative magnitudes of squares of given dimensions. [MEASURE.]

Square Number. In Arithmetic, the product of a number multiplied by itself. Thus the squares of the natural numbers, 1, 2, 3, 4, 5, &c., are respectively, 1, 4, 9, 16, 25, &c. Among the properties of square numbers, the following may be mentioned: Every odd square number is of the form $8n+1$, or when divided by 8 leaves 1 for the remainder. Every even square number is of the form $4n$, or is divisible by 4. Every square number ends with one or other of the following digits, 0, 1, 4, 5, 6, 9.

Square Root. In Arithmetic, the square root of any number is the number which being multiplied into itself produces the given number. Thus, 12 is the square root of 144, $\frac{1}{3}$ is the square root of $\frac{1}{9}$, and ·05 the square root of ·0025. When the given number is not an exact square, the root may be found to any degree of approximation by the process for extracting the square root, which is taught in every book of common arithmetic. [QUADRATIC EQUATION.]

Squares, Minimum. [MINIMUM SQUARES.]

Squared Differences of Roots. [EQUATION OF SQUARED DIFFERENCES.]

Squaring of the Circle. [QUADRATURE.]

Squarrose (Lat. squarrosus, *rough and scurfy*, perhaps akin to Gr. ἐσχάρα [ESCHAR]). In Botany, a term applied to those parts of plants which are covered with bodies spreading at right angles, or at a greater angle, from the surface which bears them, or being so arranged, as the leaves of some mosses.

Squash (another form of *quash*, from the root of Lat. quasso, Fr. casser). A variety of *Cucurbita Melopepo*.

Squatina Angelus. [KINGSTON.]

Squill. The root of *Urginea maritima*, formerly called *Scilla maritima*. Squills are imported from the Levant. The roots have a nauseously bitter and very acrid flavour, and are generally cut into slices and dried for pharmaceutical uses. There are two varieties, the red and the white; which, however, do not appear to differ materially in composition. In large doses squill is purgative and emetic; but it is chiefly employed in smaller doses as a powerful expectorant, and as a diuretic in combination with other remedies. Half an ounce of oxymel of squills is sometimes prescribed as an emetic in cases where the bronchiæ are much loaded with viscid mucus, and in the chronic coughs of old people. [URGINEA.]

Squirrel. [SCIURUS.]

Squirting Cucumber. The *Momordica Elaterium* or *Ecbalium agreste*. When the fruit or *pepo* is ripe, it separates from the stalk, and expels its seeds and a thin mucous juice with considerable violence through the remaining aperture. The acrid purgative, known in pharmacy under the name of *elaterium*, is deposited by this juice.

SS, Collar of. So called from the shape of the links; in Heraldry, in silver the badge of an esquire, in gold that of a knight, and, with several varieties in the design, that of various high officials. Its origin, according to Edmonton, 'was, no doubt, religious,' and it is said, in England, to have been originally the cognisance of the house of Lancaster, and introduced in 1407. There seem, however, to be earlier instances.

Stabat Mater Dolorosa. The first words of a celebrated Latin hymn, in rhymed lines of eight syllables without metre; said to have been composed by a Franciscan monk named Jacopone da Todi, in the fourteenth century. It has been set to music by nearly all the greatest composers. The Stabat Mater is performed in the ecclesiastical services of the Roman church during Holy Week.

Stable and Unstable Equilibrium. When a body, in equilibrium under the action of given forces, receives a very small displacement, the points of application and the directions of the forces remaining unaltered, equilibrium may still exist, and if so, it is said to be *neutral*. It may, however, be destroyed, and in this case the original state is called one of *stable* or *unstable equilibrium*, accordingly as, after the displacement, the body tends to return to, or depart still farther from, its former position. Under the influence of gravity, for example, a body is in equilibrium when the vertical through its centre of gravity passes through the point of support, and the equilibrium is stable or unstable accordingly

as a slight displacement causes the ascent or descent of the centre of gravity; it will be neutral if the altitude of the centre of gravity remains unaltered by the displacement. An egg on an horizontal plane may serve to illustrate all three states.

Staccato (Ital. *separated*). In Music, a term denoting that the notes to which it is affixed are to be detached in a marked way from each other, much like SPICCATO.

Stack (Welsh ystac, Dan. stak). Corn in the sheaf piled up in a circular or rectangular figure, brought to a point or ridge at top, and afterwards thatched to protect it from the influence of the weather, and more especially from rains. The term is also sometimes applied to hay piled up in the same manner; which, however, in most places, is called a *rick*. The foundation of a corn stack is commonly made on a platform of wood or iron, raised on props to protect it from the moisture of the soil, and also from rats and mice; differing in this respect from ricks of hay, which are built always on the ground.

Stadium (Gr. στάδιον). In Ancient Architecture, an open space used for athletic exercises. Amongst the Romans, the form of the *stadium* was very similar to that of the *circus*; but most of the Grecian stadia were surrounded by an earthen mound. Vitruvius informs us that the length of a stadium was much greater than its breadth; and that the lists were formed by a terrace, or a bank of earth. Though the stadium mostly formed part of a gymnasium, it sometimes was a part of a separate structure, and was built at great cost and with considerable elegance, as the stadium on the Corinthian isthmus, mentioned by Pausanias, and that of Herodes Atticus, at Athens, which was constructed of Pentelican marble.

STADIUM. A measure of length in use among the ancient Greeks and other nations. It was equal to 600 Greek or 625 Roman feet, or to 125 Roman paces. Hence the stadium contained 606 feet 9 inches, English. (Smith's *Dictionary of Greek and Roman Antiquities*, arts. 'Stadium' and 'Measure.')

Stadtholder (Dutch stadhouder, *city-holder*). The name formerly given to the commander-in-chief of the military forces in the republic of the United Netherlands. William I., prince of Orange, had been made governor or stadtholder of the three provinces of Holland, Zealand, and Utrecht; and during the war of independence he was continued in that office by the goodwill of those provinces. After his death, the earl of Leicester was declared stadtholder by the States-General; while some of the separate provinces appointed Prince Maurice, son of their former governor. For a century and a half afterwards the office was conferred and withdrawn by the several provinces at many different times, although always confined to members of the house of Orange. William IV. prince of Orange, in 1747, was the first general hereditary stadtholder; in 1794, the office ceased on the French conquest; in 1814, the head of the house of Orange was raised to the throne by the title of King William I.—a title retained by his successors. The power of the stadtholder varied in different provinces, and at different periods.

Staff (A.-Sax. stæf). The staff of an army consists of the officers charged with the administration of the various departments of the service. The following is the staff of the British army:—

1. General officers or colonels commanding divisions, districts, brigades, &c.
2. Adjutant-general's department. [ADJUTANT-GENERAL.]
3. Quartermaster-general's department. [QUARTERMASTER-GENERAL.]
4. Personal staff, consisting of military secretaries, assistant military secretaries, and aides-de-camp.

Officers for the staff other than personal staff must either pass through the staff college, or undergo the final examination laid down for the particular appointment, except those who attained the rank of lieutenant-colonel before January 1, 1860, or have proved their abilities in the field. Officers of the Royal Engineers are exempted from these rules.

The duties of brigade major, town or fort major, fort and garrison adjutant, correspond to those of officers of the adjutant-general's department at their respective commands.

There is also a staff, viz. adjutant, quartermaster, &c., to each regiment.

STAFF. In Music, the five lines with the spaces between them, on which music is written.

Staff Angle. In Architecture, a square rod of wood, or, in modern practice, of Keene's or Parian cement, standing flush with the finished plastering of the wall on either side, at the external angles of the plastering of the rooms, in order to oppose the tendency of the usual rendering to chip. Sometimes the staff beads are executed of copper or zinc.

Staff College. In the British Army, the school of instruction for officers who wish to be placed upon the staff of the army. It was founded in 1858, and a general order of August 25, 1863, details the qualifications necessary for admission. These are, briefly: a previous service of not less than three years; a certificate as to character and efficiency from the commanding officer; a certificate of good health and fitness for active duties from a military surgeon; a certificate of having passed the examination for the rank of captain. The candidates undergo a competitive examination in mathematics, modern languages, surveying, and military history, and the successful ones undergo a course of two years' study in the same and other subjects at the staff college. There is then a final examination, after which each officer is attached for a short time to each of those branches of the service to which he does *not* belong. He is then qualified to hold a staff appointment. There are always thirty officer students at the Staff College.

Stag. [DEER.]

Stag Beetle. The largest of British beetles (*Coleoptera*), so called on account of the length, thickness, and shape of the mandibles of the male, which resemble the antlers of a young stag, and are peculiar to the male sex. This insect (*Lucanus cervus*, Linn.) abounds in some wooded localities of the southern counties, flying about in the summer evenings, especially round the oak, on the wood of which the larva feeds, burrowing therein and passing several years in that stage of existence before its final transformation.

Stained Glass. [GLASS PAINTING.]

Stairs (A.-Sax. stæger). In Architecture, steps leading from the lower to the upper part of a house. When these are surrounded with walls or balustrades, with landing-places for the resting of the person ascending, or for communication between the several stories of a building, the whole is called a *staircase*. Vitruvius makes no mention of staircases in his treatise upon architecture; and indeed with the ancients they formed no part of the interior decoration, being generally upon the outside of the buildings. Those of which traces survive are narrow, and in some cases the steps are at least a foot in height. In modern architecture, those stairs which proceed in a right line of ascent are called *fliers*. When the steps wind round a solid or open newel, they are called *winders*. Mixed stairs are partly composed of flying and winding steps. Rondelet, after an examination of the most celebrated staircases, stated that the best proportions of the width of the tread to the rise of the steps was ascertained by the formula

$$2\,h + w = 2 \text{ ft. } 2 \text{ in.}$$

in which h would represent the height of the rise, and w the width of the tread; the length 2 ft. 2 in. being the length of the average pace of a man walking on even ground.

Stalactites (Gr. σταλακτίς, *that which drops*). Conical or cylindrical concretions of carbonate of lime attached to the roofs of calcareous caverns, and formed by a gradual dropping of water holding the carbonate in solution.

Stalagmite (Gr. σταλαγμός, *a dropping*). Stalactical formations of carbonate of lime found upon the floors of calcareous caverns, and due to the deposit of carbonate of lime from the evaporation of water fallen from the surface.

Stalk (Swed. stielk, Gr. στέλεχος). In Architecture, an ornament resembling a stalk in the Corinthian capital from which the volutes and helices spring. It is sometimes fluted.

The word *stalk* has lately been applied to the *chimney stalks*, carried up to a great height above the roofs of the buildings with which they are connected.

Stall (A.-Sax.). In Architecture, a seat raised on the sides of the choir or chancel of a church. Stalls are sometimes placed near the high altar for the priest and deacon or subdeacon; they are then called *sedilia*. At St. George's Chapel, Windsor, a stall is appropriated to every Knight of the Garter after his election and installation.

Stall-feeding. Cattle kept in stables and tied up separately, their food being brought to them, are said to be *stall-fed*. The advantages of this mode of fattening cattle are very great, both to the farmer or feeder and to the public; because much less food is wasted, and a much greater quantity of manure is produced. The disadvantages are, that more manual labour is required for cutting and carrying the food from the field to the stable; and that the flesh of the animals, for want of exercise, is not considered so high-flavoured as that of cattle which have pastured at large. To remedy this defect of stall-feeding, it is well, instead of rendering the animals fixtures by tying them up to stakes, to put them individually in so-called *boxes* about ten to twelve feet square, or to put two or three together in small yards, with a shed at one end, in which they may take exercise, shelter, or repose, according to their inclination. By this mode an equal quantity of manure is produced with less labour, and the flesh of the cattle is reckoned wholesome. When herbage plants, or grasses, are cut over only two or three times in the course of a season, instead of being continually cropped by the bite of cattle during the whole summer, the amount of vegetable produce is found to be much greater, because the plant while growing perfects a sufficient number of leaves to nourish the root; and when this produce is given to cattle in racks, in stables, sheds, or small courts, much less of it is wasted than if it were eaten on the spot where it grew. Hence, any given surface of cultivated land will produce a much greater quantity of butcher meat under crops to be mown than under herbage to be pastured; and stall-feeding, therefore, is one of the greatest modern improvements in husbandry. There can be little doubt that, with the progress of rural improvement, it will ultimately become universal; and then, and not till then, will the butcher meat of warm climates be equal to that of such climates as that of Britain. In warm climates, at present, cattle cannot be fattened by pasturing.

Stall-plate. In Heraldry, a square or oblong plate of gilt copper, upon which the arms of Knights of the Garter and of the Bath are emblazoned, and fixed in their stalls in the chapels of St. George at Windsor and of Henry VII. at Westminster. The plates now in existence date from the beginning of the reign of Henry VI., and are of great historical value.

Stallage. In Law, a duty paid for the liberty of setting up movable stalls or tables, or the like, in a fair or market; due to the owner of the soil as such, to set up stalls without whose license is trespass. When the stalls are fixed into the ground, the duty is termed *pickage*.

Stamens (Lat. stamen). In Botany, the male apparatus of a flower. The stamens are situated immediately within the petals, and

consist each of the filament, the anther, and the pollen, of which the two latter parts are essential, and the former not. They are a modified form of the petal, and are placed next it on the inside towards the centre of the flower. Independently of their physiological importance, they are much used as good marks of discrimination in systematical botany.

Staminidia (Lat. stamen). Those bodies which are supposed to be, in *Hepaticæ* and other Cryptogamic plants, the equivalent of anthers in more perfect plants.

Staminodium. In Botany, a term applied to an abortive or rudimentary stamen, or to an organ which from its position and form appears to be such. It is readily seen in the form of a scale on the corolla of *Scrophularia*.

Stammering (A.-Sax. stamer, Ger. stammeln). A term vaguely used to denote all kinds of defective utterance; but more strictly it may be described as an organic or symptomatic affection, as distinguished from *stuttering*, which is chiefly idiopathic or functional. The former is a difficulty in uttering certain elementary sounds; the latter is chiefly a difficulty in the fluent enunciation of words and sentences. Owing to the many anomalous forms which stuttering may assume, the number of remedies suggested has been very great. See an article on 'The Irrationale of Speech,' in *Fraser's Magazine* for July 1859.

Stamps. In Finance, an expedient by which a revenue can be derived from legal and other instruments, either by impressing paper, or by inserting or attaching some fabric to parchments, and providing either that the instrument shall have no legal authority except it bear this impression, or that penalties should be levied on those who construct instruments from which these government impressions are absent.

The invention of stamps as a means of revenue is ascribed to the Dutch war of independence in the sixteenth century, a crisis which was fruitful in financial expedients. They were first introduced into England by 5 & 6 Wm. & Mary c. 21, and were rapidly extended to every possible object. They were imposed on bills and notes in 1782, on foreign bills and receipts in the following year, and with some exceptions (as those on newspapers and pamphlets) have been retained in a modified form in our own time. In the case of newspapers, the stamp releases the paper from the charge of postage, to which if the stamp be not annexed the newspaper is still liable.

The word *stamp*, as is well known, is also applied to the adhesive labels affixed to letters, and first introduced after the post-office reform of 1840, though here it merely signifies a payment for a specific service.

Properly speaking, a stamp is a tax on contracts, and with rare exceptions is of doubtful expediency, because unfair and unequal in its incidence. There can be no reason, for instance, in burdening the conveyance of land, still less a pledge of land by mortgage, with a heavy tax, and exempting the transfer of other kinds of property, as merchandise, from such a liability. And the unfairness of the tax on conveying land is the more marked, because no tax was levied till lately on the succession to land, and even now the tax is lighter than that on succession to personal property. But of all taxes, none is primâ facie more just than a tax on inheritances.

The manner in which the stamp duties are chiefly secured is by prohibiting the reception of instruments in evidence unless they bear the stamp required by the law. It has consequently not unfrequently been the case, that an innocent mistake in interpreting a fiscal regulation has proved fatal to a just claim—the instrument on which the claimant relied being found to have been improperly stamped. This has been partially remedied by the Common Law Procedure Act 1854, which renders such instruments admissible in some cases on payment of the stamp duty, and a penalty, to the proper officer of the court. An unstamped instrument, though inadmissible in evidence of its contents, may yet be received in evidence for some collateral purposes, as to show illegality or fraud, and unstamped instruments are now admissible in evidence in criminal proceedings.

The all but universal evasion of the stamp duties leviable on instruments of simple contract, as bankers' drafts and receipts, led the government a few years since to substitute a uniform penny stamp in lieu of the graduated duties previously payable. No doubt this tax is not strictly defensible, as no uniform duty can be; but it is acquiesced in, partly because the amount is trifling, and, in part, because it is a relief from another system which would have been extravagantly oppressive had it not been notoriously evaded. The alteration in the stamp duties on drafts and receipts was strenuously urged on the government, by an eminent member of the Society of Friends, the late Mr. Christie. [Taxes.]

Stamper Press. A machine, of Dutch origin, used for the purpose of expressing oil by pressure through the interstices of bags. The stamper consists of a long rectangular box open at the top; at each end there are two plates, between which one bag of seed is placed, yielding a cake of 9 lbs. Next to one of the inner plates is a filling-up piece, then an inverted wedge, then another filling-up piece, after which is introduced a vertical driving-wedge, and, lastly, another filling-up piece is inserted between the driving-wedge and the other inner plate. As soon as the bags have been placed vertically in the press-box, a stamper made of hard wood, about 16 feet long and 8 inches square, with a descent of about 22 inches in the final stroke, is allowed to fall at the rate of 15 strokes per minute for a period of about 6 minutes upon the head of the driving-wedge. This is sufficient to drive it down level with the top of the press-box, the stamper being worked by two cams, or wipers, on a revolving shaft.

Side by side with the first stamper is a second one, immediately above the inverted wedge, which is held suspended at a fixed point by means of a lever, while the first stamper is in action; but as soon as it is time to remove the bags, the first stamper is raised by means of a lever above the point at which the cams come in contact with it, and by the same means the other stamper, which was previously suspended, is allowed to fall upon the inverted wedge, driving it downwards, and thereby releasing the working wedge, so that the attendant may remove the bags and repeat the operation. A press like this will do 12 cwt. of cake per day. (Fairbairn's *Mills and Millwork.*)

Stanchions. The Sea term for upright supports in general.

Stand. A Sea term, used variously; as, for example, a sail is said to *stand* well or ill. A ship is said to *stand* towards or from the shore or any object (for to *sail*). To *stand on*, to continue the course. To *stand by*, to be ready.

Standard (Ital. stendardo, Fr. étendard). In Botany, the upper and erect petal of that form of corolla which is called *papilionaceous*, from its fancied resemblance to a butterfly.

STANDARD. In Heraldry, a large square flag bearing the whole of the achievements of the monarch or nobleman, as seen in the royal standard of England. In ancient times, the royal standard, when placed before the pavilion of the monarch, either at a tournay or at an encampment, was eleven yards long and three yards broad. The length of the standard when borne in the field denoted the rank of the leader; that of a duke was seven yards long; that of a peer of lower degree, five yards; that of a knight-banneret, four. In modern times standards of peers or knights-bannerets are seldom displayed but in funeral processions. They are then long and narrow, and pointed at the ends; that of a duke is about fifteen feet in length, that of peers of lower degree, about twelve.

STANDARD. In Shipbuilding, a bracket or knee situated *above* the object to which its horizontal arm is bound.

STANDARD. A flag intended to be borne in battle. At present, in the British service, the term is applied only to the flags of cavalry regiments, other than dragoons or dragoon guards. Cavalry standards are of silk, and each regiment has two—the first or royal standard crimson, with a device upon it; the second or regimental standard of the colour of the facing of the regiment, with a different device.

Standard Measures of Length. [WEIGHTS AND MEASURES.]

Standard of Money. [MONEY.]

Stanethyl. An organo-metallic body containing tin and the organic radical ethyl.

Stanislaus, St., Order of. A Polish order of knighthood, founded by Stanislaus, king of Poland, in 1765, and renewed by the emperor Alexander in 1815.

Stannaries (Lat. stannum, *tin*). The stannary courts of Devon and Cornwall are courts of record for the administration of justice among the tinners. They are of very ancient date, and were confirmed in 33 Edw. I. They are held before the vice-warden. The appeal from the vice-warden lies to the lord warden, assisted by legal assessors, and thence to the Judicial Committee of the Privy Council.

Stannic Acid. Peroxide of tin.

Stantion, called also **Stemson.** In a wooden vessel, a timber rising within the stem, or within the apron. It forms an inner stem, and adds greatly to the strength of the fore-part of the ship. It is united by a scarf joint to the keelson.

Stanza (Ital. *station*). In Poetry, a series or number of verses connected with each other in a poem, of which the metre is constructed of successive series similar in arrangement. The stanza, however, must be understood to form a shorter division than the classical strophe, to which this definition would be equally applicable. It is so called from terminating with a full point or pause. The *ottava rima*, which consists of six lines in alternate rhyme ended by a couplet, the lines being decasyllabic or rather hendecasyllabic, is the principal Italian stanza. [OTTAVA RIMA.] The Spenserian stanza (which was perhaps invented by the poet from whom it derives its name, but certainly first applied by him to the construction of a regular poem) consists of eight decasyllabic verses and an Alexandrine at the end; the first and third verses forming the first rhyme; the second, fourth, fifth, and seventh, another; and the sixth, eighth, and ninth, a third rhyme.

Stapelia (after Dr. J. B. à Stapel, Dutch editor of Theophrastus). A genus of South African succulent-stemmed leafless *Asclepiadaceæ*, chiefly remarkable for the curious wrinkled toad-like appearance of their handsomely marbled or mottled star-shaped flowers, and the disgusting carrion-like scent emitted by most of them.

Stapes. A stirrup. One of the bones of the internal ear is so called, from its shape.

Staphyleaceæ (Staphylea, one of the genera). A small group of polypetalous *Thalamifloræ*, formerly united with *Celastraceæ*, but now recognised as having the essential characters of *Sapindaceæ*, and added by many botanists to that order as a tribe distinguished by the stamens being inserted outside instead of inside the disc, and by albuminous seeds. They consist of trees or shrubs, which are natives of Europe, Asia, and northern and tropical America.

Staphyloma (Gr. σταφύλωμα). A disease of the eyeball, in which the cornea becomes opaque and tumid, forming a white projection, sometimes resembling a grape in shape; it occasionally increases to a great extent, and requires to be removed by an operation.

Staple (Low Lat. stapulum, said to be derived from an old French word estape, signifying a mart for wine, wine being the principal

product of France). In mediæval times, certain products in the supply of which this country possessed peculiar advantages, were called *staples*, and the market for such kinds of produce was carefully regulated. Thus, wool and hides were staple agricultural produce, the sale and exportation of which were put under various limitations and conditions, the prices being fixed by statute or proclamation. So, again, tin was a staple in Cornwall, lead in Derbyshire; and on many occasions an exact control was exercised over these goods, sales being restricted to particular localities, and occasionally prohibited. Such prohibitions were, up to a comparatively late period, laid on the export of wool, and extreme penalties inflicted on those who evaded or broke the law.

In order to give importance to Calais, Edward III. fixed the staple of wool at this town; i. e. the price at which the article could be purchased by foreign buyers, especially by the weavers of the Low Countries, was determined by the rates prevailing in the Calais market. Of course there were many qualities of wool, and therefore very various prices; but the rate at which sales were effected at Calais regulated, either directly or indirectly, the market value of all wool at other marts.

The mayor of the staple was an important officer, intrusted with the maintenance of the regulations laid on staple trades. He was also empowered to take the recognisance known under the name of STATUTE STAPLE, by which a merchant, when ordinary conveyance of land was illegal, was enabled to pledge his estate for the payment of debts, and so to raise funds for carrying on his trade.

Star (Gr. ἀστήρ, ἄστρον, Lat. astrum, Ger. stern: for some remarks on the history of the word, see RISHIS). In a popular sense, the word *star* is used to designate any celestial body whatever, including the planets; but in Astronomy it is applied to those self-shining bodies, constituted like the sun, situated at almost infinite distances from us, and doubtless, like our sun, the centres of systems similar to our own.

One of the first results of the observation of the heavens was the discovery that the stars maintain always the same positions relatively to each other. Hence, they were called *fixed stars*, in distinction to the *planets* or *wandering stars*, which are constantly changing their places in the firmament. The fixity of the stars is, indeed, not absolute, for modern observations have detected changes of relative position among them; but these changes are so minute, that in general they become sensible only after the lapse of a number of years, by a comparison of position determined with the most perfect instruments at the beginning and end of the interval. They are consequently altogether inappreciable to unassisted vision, and the discovery of their existence has not rendered a change of language necessary: astronomers still speak of the *fixed stars*.

Apparent Magnitude of the Stars.—The first circumstance which arrests the attention of the observer of the stars, is the great difference in their apparent magnitudes or their relative brightness. In order to establish a gradation in this respect, and for the convenience of description and reference, astronomers divide them into classes or orders, which are called *magnitudes*. A few of the most brilliant are denominated stars of the *first magnitude*; those of an inferior degree of brightness are of the *second magnitude*; and so on down to the 6th or 7th, which, according to the established convention, comprehend the stars visible to the naked eye. The gradation is, however, still continued among those which are visible in the telescope, and magnitudes from the 8th to the 16th are familiar to those who are in the practice of using powerful instruments. It is, however, to be remarked, that this classification is not based on any photometrical determination, but is entirely arbitrary. 'Of a multitude of bright objects,' says Sir John Herschel, 'differing, probably, intrinsically, both in size and splendour, and arranged at unequal distances from us, one must of necessity appear the brightest, one next below it, and so on. An order of succession *must* exist; and it is a matter of absolute indifference where, in that infinite progression downwards from the brightest to the invisible, we choose to draw a line of demarcation. All this is matter of pure convention. Usage has, however, established such a convention; and although it is impossible to determine exactly, or à priori, where one magnitude ends and another begins, and although different observers have differed in their magnitudes, yet, on the whole, astronomers have restricted their first magnitudes to about 15 or 20 principal stars, their second to 50 or 60 next inferior, their third to about 200 yet smaller, and so on; the numbers increasing very rapidly as we descend in the scale of brightness, the whole number of stars already registered, down to the 7th magnitude inclusive, amounting to 15,000 or 20,000.' ('Astronomy,' *Cabinet Cyclopædia*, p. 374.)

The method of estimating the apparent magnitudes, therefore, usually adopted is by a scale of brightnesses decreasing in geometrical progression, each term being half of the preceding, or at least having a fixed ratio to it. Sir J. Herschel proposes and recommends the adoption of a scale decreasing as the squares of the terms of an harmonic progression, viz. the series $1, \frac{1}{4}, \frac{1}{9}, \frac{1}{16}, \frac{1}{25}$, &c. This scale is not a purely photometric one, like the former, but involves the physical idea of supposing the scale of magnitudes to correspond to the appearance of a first-magnitude star removed successively to twice, three times, four times, &c. its original or standard distance: so that upon the supposition of an equality among the real lights of the stars, the nominal magnitude would be a sort of index to the presumable distance.

Arrangement and Nomenclature of the Stars.—In order to indicate the quarter of the heavens in which any star is situated, astronomers, in

the earliest ages of the science, had recourse to the method of forming them into groups, to which they gave the name of *constellations* or *asterisms* [CONSTELLATION], and distinguished the different groups one from another by appellations borrowed in general from mythology, and suggested by vague resemblances or fanciful analogies, the origin of which it is now difficult or impossible to trace. A few of the brightest stars received particular names; some of which, conferred by the Greeks and Arabs, have been preserved, as Sirius, Rigel, Aldebaran, Arcturus, Capella, &c.; but it is obvious that this nomenclature could not be carried to any great extent. The system which has prevailed in modern times, and been generally adopted by astronomers in their charts and catalogues, was invented by Bayer, whose *Uranometria*, containing charts of all the constellations, was first published at Augsburg in 1603. It consists in distinguishing the stars belonging to each constellation by the letters of the alphabet, beginning with the brightest, which is called α. The next brightest is called β, the next in order of brightness γ, and so on; and when the letters of the Greek alphabet were exhausted, Bayer had recourse to the Roman, and then to the Italian. It is to be observed, that the order of the letters indicates only the relative brightness of stars in the same constellation, without reference to other parts of the heavens. Admitting the principle, it might have been simpler to have employed the ordinal numbers 1, 2, 3, 4, &c. for distinguishing individual stars. But great perplexity is caused by the irregular forms of the constellations, whose numerous contortions and interlacings with each other baffle the efforts of memory, and which seem, as Sir J. Herschel remarks, 'to have been purposely named and delineated to cause as much confusion as possible.'

Distribution of the Stars.—The stars are very irregularly distributed over the celestial sphere. In some regions spaces of considerable magnitude occur in which scarcely a single star is to be seen, while in others they are crowded together, so as to present to the unassisted eye the appearance of a confused mass of light. A great and rapid increase of number is in general perceptible as we approach the borders of the Milky Way, where they appear, when viewed through a powerful telescope, to be crowded almost beyond imagination. Besides the general increase which takes place towards this region, there are in several parts of the heavens patches or clusters of stars, where great numbers are condensed into a very narrow space. A telescope turned upon the Pleiades shows fifty or sixty large stars crowded together within a small area, and comparatively insulated from the rest of the heavens. Another occurs in the constellation Cancer, and is called Præsepe, or the Beehive, from the great number of stars which it presents in the telescope. In the sword-handle of Perseus and in Hercules there are also groups of the same kind, perhaps the most glorious of such objects, in which the individual stars can be distinguished in a telescope of moderate power; and in various parts of the heavens there are found luminous spots in which no star can be distinguished with ordinary telescopes, but which, when viewed through very powerful instruments, are found to consist of stars crowded together so as to occupy almost a definite outline. Many of them, says Sir J. Herschel, 'are of an exactly round figure, and convey the complete idea of a globular space filled full of stars, insulated in the heavens, and constituting in itself a family or society apart from the rest, and subject to its own internal laws. It would be a vain task to count the stars in one of these *globular clusters*. They are not to be reckoned by hundreds; and on a rough calculation, grounded on the apparent intervals between them at the borders (where they are not seen projected on each other) and the angular diameter of the whole group, it would appear that many clusters of this description must contain at least ten or twenty thousand stars compressed and wedged together in a round space, whose angular diameter does not exceed 8 or 10 minutes; i.e. in an area not exceeding the tenth part of that covered by the moon.' (*Astronomy*, p. 400.)

Number of Visible Stars.—As no limit can be set to the distance to which the stars may extend in space, the number of visible stars is limited only by the powers of the telescope. But the direct enumeration is beyond human power; and in order to obtain an approximation, it is necessary to have recourse to hypothetical considerations. By a very ingenious investigation, founded on the numbers ascertained by Sir W. Herschel to exist within certain limited spaces, Struve has attempted to compute the whole number in the heavens within the range of the twenty-foot reflector. He first establishes a law of diminution depending on the angular distance from the plane of the galactic circle [GALAXY], and having ascertained the mean number visible in the field of the telescope in that plane, he finds, by a process of integration, the whole number in the celestial vault to be upwards of twenty millions. Whether this number be near or far from the truth, it must be taken as the most probable estimate yet made. M. Chacornac, however, estimates at 77,000,000 the stars comprised in the first thirteen magnitudes.

If we confine our attention to stars visible to the naked eye, the number may be estimated with greater precision. The number of stars of the several magnitudes, in the northern hemisphere, contained in Argelander's catalogue, is as under:—

Magnitudes .	1	2	3	4	5	6
Stars in each .	9	34	96	214	550	1,439
Sums . .	9	43	139	353	903	2,342

Assuming the *density* to be the same in the southern hemisphere as in the northern, the catalogue should contain 4,684 stars. It is estimated by Struve, that the number entered

in the catalogue is to the whole number existing (and visible to the naked eye) within a given space, in the ratio of 8,136 to 10,000. Hence the whole number of stars which can be seen with the naked eye is 5,757, i. e. less than 6,000. The number of stars down to the ninth magnitude already registered and mapped amounts to nearly 300,000.

Distance.—Although it is a very improbable supposition that all the stars are of the same size, it is equally improbable that their real magnitudes are in any way dependent on their distance; but unless this latter supposition be made, we must conclude that, *on the average* (putting individual cases out of view), the most distant will be those which have the smallest apparent magnitude.

Argelander, of Bonn. has given a catalogue of the stars visible to the naked eye, in which they are divided into six orders of magnitude; the faintest stars, or those just perceptible by the naked eye, being considered as the smallest, or the sixth magnitude. If we suppose six concentric spheres to be described about the sun, with radii such that the first contains all the stars of the first magnitude, the second all those of the first and second magnitude, the third all those of the first three magnitudes, and so on; and if we also suppose the *mean* distance of the stars of the first magnitude to be unity, then, according to the computation of Struve (founded necessarily on certain hypothetical assumptions respecting the distribution of the stars in space), the mean distance of the stars of the different orders of magnitude, and the radii of the spheres circumscribing them, as above supposed, are as follow:—

Magnitudes	Mean Distance	Radius of Sphere
1	1·0000	1·2638
2	1·8031	2·1408
3	2·7639	3·1961
4	3·9057	4·4374
5	5·4545	6·2093
6	7·7258	8·8726

For stars of the next three magnitudes, the data for computing the relative distances have been furnished by Bessel's zone observations. Struve finds the radii of the circumscribing spheres to be as follow: For those of the seventh magnitude, 14·4365 units; for those of the eighth 24·8445; of the ninth 37·7364; and, lastly, he concludes that the smallest stars observed by Sir William Herschel with his twenty-foot reflector are at an average distance of 227·8 units, or 25·67 times more distant than the smallest stars visible to the naked eye. (*Etudes d'Astronomie Stellaire*, p. 81.) So much for estimation. The element from which the distance can be actually deduced is the annual parallax, or the angle subtended by the diameter of the earth's orbit at the distance of the star [PARALLAX]; this distance is so great that, except in a few instances, all the attempts of astronomers to determine it have hitherto been fruitless; in other words, at the distance of the star, the diameter of the earth's orbit, a line some 180,000,000 miles long, is not of sensible dimensions. We know, for instance, that from α Centauri the radius of the earth's orbit would be hidden by a thread $\frac{1}{25}$ of an inch in diameter, held at a distance of 650 feet from the eye.

We give below a table of the principal distances already determined, expressed in radii of the earth's orbit; they can be converted into miles by multiplying them by the length of that radius.

The number of years required by light to travel the different distances is also shown:—

	Radii of Earth's Orbit	Years
α Centauri . . .	211,330	3·6
61 Cygni . . .	550,920	9·4
Vega.	1,330,700	21·0
Sirius	1,375,000	22·0
ι Ursæ Majoris .	1,550,800	25·0
Arcturus . . .	1,622,800	26·0
Polaris	3,078,600	50·0
Capella	4,484,000	72·0

The distances of other stars are also known, but with less precision. None, however, are less than the distance of α Centauri. It is no extravagant supposition that there may be others still visible which are a thousand times more remote. If, therefore, one of these were annihilated, some ten thousand years would elapse before its extinction could be perceived at the distance of the earth.

Real Magnitudes.—The only means formerly possessed of obtaining any indication respecting the real magnitudes of the stars was by means of the quantity of light received from them. Sir J. Herschel compared the light of α Centauri directly with the moon, and from several experiments, made with attention to all the circumstances required to be taken account of, found that the mean quantity of light radiated to the earth by a full moon exceeds that sent by α Centauri in the proportion of 27,408 to 1. Dr. Wollaston (*Phil. Trans.* 1829) found the proportion of the sun's light to that of the full moon to be that of 801,072 to 1. Combining these results, it appears that the light sent to us by the sun is to that sent by α Centauri as 21,955,000,000, or about twenty-two thousand millions to one.

A knowledge of the distances of the stars does not help us to determine their real dimensions, as has been done in the case of the planets and the sun, for the apparent diameter of the most brilliant stars is so small that it defies all measurement.

If, however, we suppose that the intrinsic intensity of the light be the same for Sirius (for example) as for the sun of our system, we shall arrive at pretty clear, if only conjectural, views on the dimensions of this magnificent star. On this hypothesis, the diameter of Sirius would be fifteen times that of our sun; so that, even in granting to its light an intrinsic brightness triple that of the sun, the dimensions of Sirius would still be five times greater, and its volume would be 125 times that of the sun.

Proper Motions of the Stars.—On comparing

the places of the stars determined by recent observations with the positions assigned to them in the older catalogues, it is found that many of them have undergone a very sensible displacement. Within the last fifty years the double star 61 Cygni, above mentioned, has moved through 4′ 23″ of right ascension; and as the motion appears to be uniform, its rate is therefore about 5·3″ annually. Another star (μ Cassiópeiæ) has an annual proper motion of 3·74″. The number of stars in which such motion has been detected, though of smaller amount than in the above instances, is very considerable. Out of 2,959 stars in the catalogues of Bradley and Piazzi, Bessel found 425 having a proper motion of not less than 0·2″. The discovery of the existence of such changes in the places of the stars gives rise to some interesting speculations relative to the constitution of the universe. That the stars gravitate to each other like the bodies of the solar system is rendered certain from the phenomena of binary stars; and when we admit the prevalence of this force among them, we are led to suppose a centrifugal force to be necessary to counteract the tendency to a general collapse produced by their mutual gravitation. Hence, we conclude that the proper motions must be performed in circular or elliptic orbits round some very remote centre; and as every appearance leads us to suppose the stars to be bodies of the same nature as our own sun, it becomes extremely probable that the sun with its attendant system is transported through space with a similar motion. Now, the translation of the solar system would necessarily give rise to an apparent change of the positions of the stars; for in consequence of the diminution of distance, they must appear to recede from that point of the heavens towards which the sun's motion is directed, and to converge and become more condensed in the region diametrically opposite. Sir William Herschel was of opinion that this is what actually takes place, and that a general recess of the principal stars from the point occupied by ζ Herculis is already indicated by the catalogues, and consequently that the solar system is carried forward in the direction of that star. It seems, however, to be the opinion of astronomers at present, that the observations are not yet sufficient to establish the certainty of this motion; but whether the supposition shall be confirmed or not, it would appear that all the proper motions which have been remarked cannot be accounted for in this way. It is a curious circumstance, and was first noticed by Bessel, that a large proportion of the stars which have a proper motion are double stars. The most decided case of proper motion lately recorded is that of Sirius, which is now known to have one or more companions.

Arcturus in a century traverses the eighth part of the diameter of the moon. α Centauri, in the same interval of time, is displaced a quantity measured by the fifth of this diameter.

To determine the real velocity of a star from the proper motion, the distances of the stars of which the proper motion is measured must be known. We give a table of some velocities which have been thus determined:—

	Miles per second
Arcturus	54
61 Cygni	40
Capella	30
Sirius	14
α Centauri	13
Vega	13
Polaris	1½

Variable and Periodic Stars.—Proper motion is not the only indication of the existence of active forces in the stellar regions. Many stars have been observed whose light appears to undergo a regular periodic increase and diminution of brightness, amounting in some instances to a complete extinction and revival. Of this kind one of the most remarkable is the star *Omicron* in the constellation Cetus, or the Whale, which has a period of about 334 days. At its greatest brightness it is a star of the second or third magnitude, and continues in this state about a fortnight, when its light begins to wane, and at the end of three months it becomes for some time invisible to the naked eye. Algol, in the constellation Perseus, appears for about 62 hours as a star of the second magnitude; its light then suddenly diminishes, and in about 3½ hours it is reduced to the fifth magnitude: it then begins to revive, and in the space of 3½ hours more it is restored to its original state, thus accomplishing its period in about 69 hours. The star δ Cephei has a period of about 5 days 8½ hours, and β Lyræ one of 6 days 9 hours. A star in the breast of the Swan has a period of about 15 years, during five of which it is invisible. Various other similar instances have been remarked; and the variable stars already catalogued amount to a large number.

Temporary Stars.—On examining ancient catalogues, it is found that some stars formerly distinguished by their splendour have entirely disappeared, no stars being now found in the places which they are set down as having occupied. Others have suddenly shone forth with extraordinary brilliancy, and after a longer or shorter period have gradually died away, and become extinct. A phenomenon of this kind, about 125 years B.C., induced Hipparchus to undertake the formation of his catalogue. In the year 389 of our era a star suddenly blazed forth near α Aquilæ, and remained for three weeks as bright as Venus, and then disappeared. But one of the most remarkable instances is that of the star which appeared in 1572, and was observed by the astronomer Tycho Brahe. It suddenly shone forth in the constellation Cassiopeia, attained a splendour equal to that of Jupiter and Venus when nearest the earth, and could be seen by the naked eye at mid-day. Its brightness gradually diminished, and at the end of sixteen months it disappeared, and has never been seen since. During the time of its visibility, its

apparent place remained unchanged. All the phenomena attending it are fully described by Tycho in his work entitled *De Nova Stella Anni* 1572. A similar phenomenon occurred in the year 1604, in the constellation Serpentarius, of which an account is given by Kepler (*De Stella Nova in Pede Serpentarii*, Pragæ 1606). For various other instances of a similar kind, and also of stars set down in the catalogues, but which cannot now be found, the reader is referred to Lalande's *Astronomie*, tome i. p. 259.

There is reason to believe that the so-called new and temporary stars are nothing but variable stars viewed at the period of their greatest brilliancy. Tycho Brahe's star, discovered in 1572, has been recently paralleled by a new star which made its appearance in *Corona Borealis*. In a few days its light was reduced from the 3rd to the 9th magnitude; and the application of the spectroscope, that most powerful instrument of research of modern times, showed it with a spectrum resembling that of our sun and the other stellar bodies, but with the difference that in addition to this, a gaseous spectrum, overlying the other, as it were, seemed to indicate the existence of an atmosphere of hydrogen in a state of incandescence enveloping the star.

Double and Multiple Stars.—Many of the stars which appear to the naked eye, or telescopes of feeble power, merely as bright points, are found, when observed with high magnifying powers, to be composed of two, and some of them of three or more stars, in close juxtaposition. This appearance may arise from the circumstance of two stars being situated in nearly the same line of view; for it is evident that two stars thus placed would appear as a double star, however great the real distance between them may be. It was suggested by Galileo that the variations (if sensible) of the apparent distance between two contiguous stars would furnish a good method of determining the annual parallax; and a series of observations on double stars was undertaken by Sir William Herschel with a view to this question. The result, however, was a discovery of a very different kind; for instead of finding an alternate increase and decrease of the apparent distance between the two stars, which would be the consequence of an annual parallax, he observed in some instances a regular progressive change from year to year in one direction. By reason of the slowness of the apparent motion, a considerable interval elapsed before he was able to determine its laws; but it was explicitly announced by him in 1803 that there exist sidereal systems composed of two stars, one revolving round the other, or both about a common centre. Subsequent observations have fully confirmed this discovery; and in some instances even the ellipticity of the orbits and the periods of revolution have been determined. Some of these binary systems, as they are called, have periods of great length; but in such cases the periods, being computed from observations extending over only a small part of the orbit, and liable besides to considerable uncertainty, cannot be held to be determined with much precision. Thus, the period of Castor has been computed by Sir J. Herschel to be 252 years, and by Mr. Hind to be 632 years. A period of 629 years was assigned to γ Virginis, but Sir J. Herschel has found that the observations are better represented by an orbit in which the time of revolution is 182 years. The period of 61 Cygni is supposed to be about 500 years. There are others, however, having much shorter periods, and which have already been observed through their entire orbits. The star η Coronæ, for example, has a period of little more than 43 years, and has consequently completed nearly two revolutions since its discovery as a double star by Sir William Herschel in 1761. ζ Ursa Majoris has a period of about 58¼ years, and 70 Ophiuchi one of about 80 years. Since the time of Sir William Herschel the observations of double stars has been a subject of much interest in astronomy, and catalogues containing some thousands of them have been published, giving the apparent distances of the two bodies, and their angles of position, or the direction of the straight line which joins them, by comparing which with future observations their orbits and periods will become known. (Herschel and South, *Phil. Trans.* 1826; Herschel, *Memoirs of the Royal Astronomical Society*, vol. iii.; Struve, *Catalogus Stellarum Duplicium et Multiplicium*, Petropoli 1837; Herschel, *Outlines of Astronomy*, 1864.)

Some of the binary systems afford curious instances of contrasted colours, the colour of the smaller star being frequently complementary to that of the larger. In such instances the larger star is usually of a ruddy or orange hue, and the smaller one blue or green. Sir J. Herschel thinks it probable that the colour of the small star is the effect of the brighter light of the large one; for it is a general law of optics that when the retina is under the excitement of any bright-coloured light, feebler lights for the time appear coloured with the complementary tints. This opinion seems strengthened by the fact that though insulated stars of a red colour, almost as deep as that of blood, appear in many parts of the heavens, no green or blue star (of any decided hue) has been noticed unassociated with a companion brighter than itself; but, on the other hand, several instances are known in which a blue or green star retains its colour in an undiminished degree when its more brilliant neighbour is concealed from the field of view of the telescope. The application of the spectroscope has further taught us that absorption varies very largely in these bodies.

On this account the celestial scenery in the various multiple systems composed of coloured stars must be of the most gorgeous description. In an extremely remarkable group, situated in the Southern Cross, near the star Kappa, among the principal stars two are red and ruddy, one is of a greenish blue, two are

green, and three others are of a pale green. 'The stars which compose it, seen in a telescope of diameter large enough to enable the colours to be distinguished, have the effect,' says Herschel, 'of a casket of variously coloured precious stones.'

Sir John Herschel remarks on this subject: 'It may be easier suggested in words than conceived in imagination what variety of illumination *two suns*—a red and a green, or a yellow and a blue one—must afford a planet circulating round either; and what charming contrasts and "grateful vicissitudes"—a red and a green day, for instance, alternating with a white one and with darkness—might arise from the presence or absence of one or other, or both, above the horizon.'

For the structure of the sidereal universe of which our sun forms a part, the reader is referred to the article GALAXY.

Star Anise. The fruit of *Illicium anisatum*, an evergreen growing in Japan and Cochin China. The seeds have the odour of common anise, and yield, when distilled with water, an oil sometimes called *Oleum badiani*, which is used by liqueur makers.

Star of Bethlehem. The popular name for *Ornithogalum umbellatum*.

Star Chamber, Court of (Curia Cameræ Stellatæ; from the ornaments of the ceiling of the room in which at one period it sate). This court was originally the privy council itself, 'sitting in the Star Chamber,' and there exercising important criminal jurisdiction, and administering equitable relief. It is mentioned as early as the reign of Edward III. In the third year of Henry VII. an Act was passed giving to the Court of Star Chamber determinate criminal powers, extending chiefly to state offences and misdemeanours of a public kind. The judges were four high officers of state, with power to add to their number a bishop and a temporal lord of the council, and two justices of the courts of Westminster. They proceeded by bill and information without the assistance of a jury. The sittings of the privy council itself, as a criminal court, were after this gradually abandoned, and its powers transferred to the Star Chamber. This court continued to exercise very extensive jurisdiction, both in political matters and in private concerns, during the reigns of Henry VIII. and his successors, until it was finally dissolved by 16 Ch. I. c. 10, together with what remained of its cognate jurisdictions. [COUNCIL, PRIVY.]

Star Fort. A fort with several salient angles, in shape something like a star. [FORTIFICATION.]

Star of India. An order of knighthood instituted by Queen Victoria in 1861, for the purpose of rendering honour to conspicuous loyalty and merit in the princes, chiefs, and people of her Indian empire. It consists of the sovereign, a grand master (who is always to be the governor-general of India), and twenty-five knights, with such honorary knights as the crown may appoint, the knights to include military, naval, and civil officers, and natives of India. The insignia of the order are, a collar, investment badge, and star, with the motto, 'Heaven's Light our Guide.' (Boutell's *Heraldry*.)

Starboard. The right-hand side of a ship, looking forwards.

Starch (akin to stark, *stiff* or *strong*). Starch is one of the commonest proximate principles of vegetables. It is characterised by its insipidity, and by insolubility in cold water, in alcohol, and in ether. It dissolves in, or at least forms a gelatinous compound with, water heated to 175°; and this solution, even when much diluted, is rendered blue by iodine. This admirable test of the presence of starch is not effective in hot solutions; and by boiling the blue colour disappears, but returns in strong solutions as they cool. The term *starch* is commercially applied to that obtained from wheat, which for this manufacture is ground and diffused through vats of water, where it undergoes a slight fermentation, and acquires a peculiar sour smell. A part of the gluten and albumen of the grain is thus separated in the form of a viscid scum. The starch, being in the form of a finely divided white powder, is gradually further separated by washing in large quantities of water, from which it is ultimately allowed to settle, and put into wicker baskets lined with linen to drain. It is then cut into squares, which are dried first in airy chambers upon porous bricks, and afterwards rolled up in papers and *stove* dried. In this latter operation the starch acquires that peculiar columnar texture and fracture which is well exhibited in opening a paper parcel as it comes from the stove. A little *smalt* is generally added to the starch, by which it acquires a very pale blue tint, and is better adapted to conceal or cover the yellow tint acquired by worn linen. Starch may be obtained from many other grains, and from potatoes and several other esculent vegetables. *Arrowroot* is the starch of the *Maranta arundinacea*; *sago*, of the *Sagus farinifera*, an East Indian palm-tree; and *tapioca* and *cassava* of the *Manihot utilissima*. Viewed under the microscope, the varieties of starch exhibit a more or less distinct globular appearance, and are said to be made up of little spherical particles of soluble starch, enveloped in an insoluble membrane, which protects the interior from the action of cold water, but which is broken or burst by hot water. In the progress of germination, and by various chemical agents, starch may be converted into gummy and saccharine matters. [DEXTRINE; DIASTASE; GLUCOSE.]

Starkey's Soap. A compound of turpentine, or oil of turpentine, and alkali.

Starling. A small social species of the conirostral tribe of perching birds (*Insessores*), allied to the crows. Our common starling (*Sturnus vulgaris*, Linn.) is mainly insectivorous, collects in large flocks in autumn, is readily tamed, and taught to warble and imitate human speech.

Starost. A title under the Polish republic enjoyed by noblemen who were in possession of certain castles and domains called *starosties*. These were grants of the crown, and conferred only for life, but generally renewed after the demise of a possessor to his heirs.

Starstone. A variety of sapphire, which, when cut and viewed in a direction perpendicular to the axis, presents a peculiar reflection of light in the form of a star. It is found in Ceylon, and is usually cut *en cabochon*, or in a hemispherical form. It is the Asteria of Pliny and the ancients.

Starting Gear of an Engine. The mechanism by which the motion of an engine is begun, and which is of a very different kind in different classes of engines. Many large engines are provided with a small steam engine to start them, and some are provided with starting valves. In every species of starting gear, the indication to be fulfilled is to enable the steam to press upon one side of the piston, while the other side is open to the atmosphere or condenser. [STEAM ENGINE.]

State Rights. The various *plantations* or settlements which were ultimately consolidated into the American Union, in 1782, or which were afterwards added to it by conquest, purchase, or occupation, had at the outbreak of the War of Independence, or as from time to time they were made to form part of the Union, a great variety of laws and constitutions, not a few discrepant political and commercial interests, and very well marked social differences. The harmonising of these laws, interests, and differences, was part of the work of those who first established the Union; a work which required infinite tact, sagacity, patience, and perseverance. For instance, so slight (in the opinion of those who formed the federal constitution) was the bond which was to form the basis of the political and diplomatic unity between the different states, that Franklin concealed his discovery of the Gulf Stream till some years after the acknowledgment of American independence, lest the possible diversion of European trade from Charlestown to New York might render the inhabitants of Carolina disaffected towards the national cause. Thus, again, although before the commencement of the War of Independence the Quakers of Pennsylvania had determined on excommunicating all members of the Society of Friends who kept slaves in their possession, and although Wesley had denounced slavery in the American plantations as 'the sum of human villanies,' and had called into existence among his followers a strong abolition party, slavery was permitted as a state institution, to be maintained or annulled according to the pleasure of the local legislature. On the other hand, the slaveholding states, in order to effect a compromise, were obliged in turn to accede to the protectionist theories of the North, and to copy the republican principles of equality which were far from the practice and habits of the early planters of Virginia and the Carolinas.

The Act of Independence declared the Union to be one and indivisible, while it recognised the internal legislation and self-government of the several states. Thus, for instance, all tariffs from which customs duties were to be collected, the right of declaring peace and war, the election of the chief officers of state, the management of the public debt, the occupation of forts and arsenals, the administration of the army and navy, the supervision of harbours and lighthouses, remained in the hands of the federal government, and of the congress and senate assembled in Washington (i.e. the legislative and political capital of the Union), a city which, with the district of Columbia surrounding it, formed, as it were, a sort of administrative metropolis.

On the other hand, the internal organisation of the several states was left to the conduct of the local legislatures. These states had each its parliament or congress and its governor. These parliaments could impose taxes, to be applied solely to state purposes; could legislate on a variety of subjects, such as the tenure of land, the right of succession, marriage, and divorce, religious and educational endowments, the social status of the various persons who formed the electoral body; could borrow money for roads and canals; and, whether small or great, contributed an equal number of representatives to the senate.

In time of peace, and when the Union was not burdened by debt, the functions of the congress and senate were comparatively unimportant. The executive was almost entirely in the hands of the president and his cabinet. The ministers do not, as in England, depend on the good will of parliament, but are nominated and retained in office solely at the will of the president. Hence the congress and senate (though they had together important powers) were, in effect, more a debating club than a legislature, and exercised but little influence on the foreign policy or the public law of the states; and conversely, the local legislature in the several states occupied a very important position, and was becoming increasingly independent of the central authority.

The divergence of interests, economical and social, which characterised the northern and southern portions of the Union, and the jealousies constantly developed from such a divergence, continually threatened a rupture between political parties, and with it a dislocation of the Union. The several states were constantly disposed to treat the authority of the Washington government and parliament with contempt, and, under the name of *nullification*, to render themselves all but independent of the central authority. There cannot, indeed, be a doubt that the Union was at first voluntary, and that there was, from the excessive devotion of the people to what were called in very early time state rights, no slight colour in the assertion, that the sepa-

ration between the two sections of the Union, which was often threatened, was the inherent right of all the states which had formed the original pact. It might, of course, be objected, that such a theory would justify a still further subdivision; that all social contracts are in their beginning voluntary, or at least are admitted so to be in a republic; but that the developement of this principle would be the dissolution of society altogether. It might further be urged, that the federal constitution proclaimed the Union to be indissoluble, and that it by no means follows that nations who are dissatisfied with the results of a voluntary act, can quit themselves of the obligation, any more than a private person can disclaim a formal and legally executed deed.

The administration of the states was by no means faultless. This was shown strikingly in the various acts of repudiation committed by many of the wealthiest states. Ten of these repudiated obligations incurred to state creditors, most of these debts having been contracted for manifest, and on the whole enduring, public benefits. The forcible appeal of Sydney Smith to the congress of Washington is well known. But the temptation to repudiation was very strong. States, like individuals, need that their conscience should be stimulated by the risk of discovery and punishment; and in general, communities having diplomatic relations with other countries find it necessary to be honest, in order that they may have any place in the world's markets. The several states of the Union, however, were under no such control; they stood in no diplomatic relation to any but the Washington government.

The doctrine of state rights culminated in secession. It is well known that opinions were strongly divided in Europe, and even in the United States, as to the justification of this act. It should be noted, however, that immediately on the commencement of the civil war, the question was distinctly settled, and the maintenance of the Union, at any risk, loss, or cost, became, for very obvious reasons, a passion among the great mass of the American people. The success of secession, to the mind of most American statesmen, implied the maintenance of vast standing armies, and ultimately of political retrogression. Any sacrifice, it was felt, was trivial compared with the enormous evils of maintaining an imaginary frontier extending for thousands of miles, and separating by no natural barriers two states, or two aggregates of states, whose disunited interests were and would be intensely irreconcilable. At present (1866), the contest, happily only political, which is raging in the United States, bears testimony to the tenacity with which the several communities composing the Union cling to the right of domestic legislation, even when the exercise of this right would imperil all the results of the war, by stereotyping distinctions of race.

It can scarcely be doubted that state rights, in so far as they are aggressive, or antagonistic to the general interests of the American people, will be modified. The memory of past sacrifices, losses, expenses, and debts, will effect much; the increasing importance of congress will effect far more. At present, congress has on its hands the management of an enormous debt. The charges of this debt, in part met by direct taxation, are in great measure liquidated by customs and excise duties; the former being, in accordance with the protectionist theory, to which recent events have given temporary strength, by far the most onerous and inconvenient to the mass of the community. But no one can doubt that before long protection will be assailed in congress, and that this body, whose functions have up to the war been comparatively unimportant, will have to devote much attention to these national questions, and will become a field for the exercise of great financial and political skill. In such a case the local legislatures will occupy a very inferior position.

Stater (Gr. στατήρ). An ancient Greek measure of value. It was undoubtedly a coined piece of money at an early period. The common gold currency in the republican times of Greece consisted of staters. The Attic golden stater weighed two drachms, and is estimated at twenty silver drachms; but the value of the coin struck by different states with this denomination varied greatly.

States or **Estates** (Fr. états, Ger. stände). In modern European History, those divisions of society, professions, or classes of men, which have partaken, either directly or by representation, in the government of their country. Their number has varied in different countries. In France, and most other feudal kingdoms, there have been three estates (nobles, clergy, commonalty), members of the ancient national assemblies. Hence the well-known appellation *tiers état* (third estate) for the last. In Sweden there are at this day four: nobility, clergy, citizens, peasants. In most countries the ancient system of assemblies convoked from separate estates disappeared by the progress of absolute government in the sixteenth and seventeenth centuries; and in modern monarchical constitutions the English system of government, by king, lords, and commons, or analogous powers, has for the most part prevailed.

States-General. In French History, assemblies which were first called A.D. 1302, and were held occasionally from that period to the year 1614, when they were discontinued, till they were summoned again in the year 1789. These states-general, however, were very different from the ancient assemblies of the French nation under the kings of the first and second race. (Hallam's *Middle Ages*, ch. ii. part ii.) There is no point with respect to which the French antiquaries are more generally agreed than in maintaining that the states-general had no suffrage in the passing of laws, and possessed no proper jurisdiction. The whole tenor of French history confirms this opinion. [ASSEMBLY; DIRECTORY.]

Statics (Gr. ἡ στατική, sc. ἐπιστήμη, *the*

science of weight). The branch of Mechanics which has for its object the investigation of the conditions of equilibrating forces, or the conditions under which several forces applied to a rigid body mutually destroy each other.

There are three general principles on which the theory of equilibrium may be grounded; these are: 1. The principle of the lever; 2. The principle of the composition of forces; and 3. The principle of virtual velocities.

Principle of the Lever.—The equilibrium of a straight horizontal lever, loaded at its extremities with weights which are reciprocally proportioned to their distances from the fulcrum, was demonstrated by Archimedes [LEVER]; and it is easy to extend this principle to the bent lever, when the fulcrum is at the angular point, and to show that if the two arms be urged in opposite directions by two forces perpendicular to the arms and reciprocally proportioned to their lengths, there will be equilibrium. Now, it is an axiom in statics that a force may be regarded as acting at any point whatever in the line of its direction; and hence it follows that any two forces, applied at any points whatever in a plane which is only movable round a fixed point, and having any directions whatever in that plane, will be in equilibrium when they are to each other reciprocally as perpendiculars drawn from the fixed point to their lines of action; for the perpendiculars may be regarded as the arms of a bent lever having the fixed point for its fulcrum. This general principle, which is also called the *principle of moments*, suffices for the resolution of all the problems of statics, and is indeed the only one which was rigorously demonstrated before the discovery of the composition of forces, i. e. before the publication of the *Principia* in 1687.

Composition of Forces.—The second general principle consists in this, that any two forces acting together upon the same point of a body are equivalent to a single force represented in intensity and direction by the diagonal of a parallelogram, the sides of which represent the two given forces. This equivalent of the two forces is called their *resultant*; and as the resultant may be combined with a third force acting on the same point, and the resultant of this composition with a fourth, and so on, it follows that any number of forces applied to the same point have a single resultant, or may be replaced by a single force. [FORCE.] This principle was not known to the ancients. Galileo demonstrated that a body moved by two uniform velocities, the one vertical and the other horizontal, must acquire the velocity represented by the hypothenuse of the right-angled triangle, whose sides represent respectively the two velocities. This is a particular case of the principle. Newton proved it to be true generally, and substituted the composition of forces for that of motions; and in the second corollary to the third law of motion, he shows how the laws of equilibrium may easily be deduced from it. The *Nouvelle Mécanique* of Varignon, published in 1725, contains the first complete theory of the equilibrium of forces in different machines, deduced solely from the principle of the composition of forces. The simplicity of the principle, and the facility of its application to all questions connected with equilibrium, caused it to be almost immediately adopted; and it is the basis of all the modern treatises on statics.

Virtual Velocities.—If we conceive the body to which a system of forces is applied to be slightly displaced, and multiply each force by the velocity of its point of application, estimated in the direction of that force, *the algebraical sum of the products thus formed will vanish if the forces be in equilibrium*; and conversely, *if the sum vanish the forces will be in equilibrium*. This is the third general principle on which the conditions of equilibrium may be made to depend. It applies almost self-evidently to the conditions of equilibrium of the lever, pulley, and other simple machines. Its generality was first remarked by John Bernoulli. It has been adopted by Lagrange, as the basis of his *Mécanique Analytique*; and it has the advantage over the others of being capable of representation in a single general formula, which includes the solution of every question that can be proposed relative to the equilibrium of forces. Lagrange, however, remarks that it is not sufficiently self-evident to be erected into a primitive principle; but it may be regarded as a general expression of the laws of equilibrium deduced from the two former principles. [VIRTUAL VELOCITY.]

The general problem of statics consists, as above remarked, in the determination of the conditions of equilibrium of a body under the action of a given system of forces or pressures.

These conditions are expressed by the following *six equations of equilibrium*, which may be at once deduced from the principle of the COMPOSITION AND RESOLUTION OF FORCES AND COUPLES.

$$\Sigma P_i \cos \alpha_i = 0, \quad \Sigma P_i \cos \beta_i = 0, \quad \Sigma P_i \cos \gamma_i = 0,$$
$$\Sigma P_i (y_i \cos \gamma_i - z_i \cos \beta_i) = 0,$$
$$\Sigma P_i (z_i \cos \alpha_i - x_i \cos \gamma_i) = 0,$$
$$\Sigma P_i (x_i \cos \beta_i - y_i \cos \alpha_i) = 0.$$

Herein P_1, P_2, &c. denote the given forces, $\alpha_i, \beta_i, \gamma_i$ the direction cosines of any one of them, say P_i, with respect to any rectangular co-ordinate axes, and x_i, y_i, z_i the co-ordinates of any point in the line of action of P_i; the summation is, of course, to be extended to all values of i corresponding to the given forces. The application of these equations to special problems is explained in all treatises on mechanics. The classical work on the subject is Poinsot's *Elémens de Statique*; Möbius's *Statik* is also a most instructive work; the principal contents of both, however, are collected in every good English text-book, of which a few have been already cited in the article MECHANICS.

Station (Lat. statio). In Astronomy, a

planet is said to be at its *station*, or to be *stationary*, when its motion in right ascension ceases, or its apparent place in the ecliptic remains for a few days unaltered. The real motions of the planets are always in the same direction from west to east; but owing to the motion of the earth from which they are seen, their *apparent* motions, though generally from west to east, or direct, are sometimes from east to west, or retrograde, and in changing from one of these directions to the other the planet appears for some short time to stand still. The distance of the earth and of a planet from the sun being given, and also their periodic times, the determination of the arc of retrogradation, or the times at which the planet will appear stationary, is an easy problem; but to the ancient astronomers, who were unacquainted with the relative distances of the planets, and who, moreover, supposed the earth to be the centre of motion, the phenomena of the stations and retrogradations occasioned great embarrassment, and the principal object of the various systems which were propounded previous to that of Copernicus was to give a satisfactory explanation of them. [EPICYCLE; PLANET.]

STATION. In Shipbuilding, the same as ROOM AND SPACE.

STATION. In Surveying, the place selected for planting the instrument with which an angle is to be measured.

Station Pointer. An instrument used in maritime surveying, for expeditiously laying down on a chart the position of a place from which the angles subtended by three distant objects, whose positions are known, have been observed. It consists of three scales, which move about a common centre. Two of these carry divided circular arcs, and the third is provided with two verniers adapted to the arcs, by means of which the scales can be opened so as to form any two angles. If we suppose the angles of the scales to be made equal to the two measured angles, and the instrument to be laid on the chart, so that the edges of the three scales coincide with the positions of the observed objects, the centre will mark the position of the spot from which the objects were observed. (Simms' *Treatise on Mathematical Instruments*, p. 98.)

Stations (Lat. statio, *an outpost*). In Ecclesiastical Antiquities, the weekly fasts of Wednesdays and Fridays. These were omitted between Easter and Whitsuntide. They terminated at three in the afternoon; hence sometimes called *semijejunia*. Saturday was made a station day by the council of Elvira; and this, it is said, led to the gradual neglect of the Wednesday station in the Western church.

The term *station* is also applied to certain points in the narrative of the passage of Christ from the judgment-seat to the cross, which are selected by the Roman Church as subjects for meditation, and are well known through the pictorial representations common in Roman Catholic churches.

Stations, Railway. Buildings erected for the reception of the passengers and goods intended to be transported by railways. These stations are either terminal stations or side stations. The terminal or main stations frequently divide their business into two parts, and one portion of the station is devoted to the reception of passengers, and the other portion to the accommodation of goods; or sometimes there are two different terminal stations, one for goods and the other for passengers.

Terminal or main stations are often of great extent, and of a complex character, as, in addition to the structures required for the reception of goods and passengers, carriage dépôts and locomotive workshops are comprehended in the general design. In such stations there must be provided booking offices, where the several classes of passengers take their tickets; waiting-rooms for the first, second, and third class; refreshment-rooms, luggage office, and various other requisite accommodations. Generally, too, the chief offices of the railway company, with proper apartments for the secretary and clerks, and a board room for the directors, are situated at the principal terminal station of a railway. There are also platforms both for the arriving and departing trains, and platforms for loading and unloading luggage, with proper hoisting gear driven by steam. There are also lamp rooms and rooms for the accommodation of the attendant porters; and there is always a system of turn-tables, or other analogous arrangements, for transferring the engines and carriages from one line to the other.

The most remarkable feature of railway stations is the roof, which covers the platforms where the trains are received and despatched, the area covered being often very great, and the roofs being sometimes of very large span. These roofs are generally formed with wrought iron ribs or rafters properly trussed, but sometimes they are made of timber. In the new station at St. Pancras, designed by Mr. Barlow for the Midland Railway, the area covered is 690 feet by 240 feet. The main ribs are 29 feet 4 inches from centre to centre, with three intermediate ribs at equal distances between them, carried at every 18 feet 6 inches by trussed purlins between the main ribs. The ribs spring directly from the ground, and are firmly connected to massive brick piers below the floor level. The curve of the ribs is formed with two radii of 160 feet and 57 feet meeting in an angle at the centre 100 feet above the level of the rails. The ribs are 6 feet deep, and are formed with open box flanges 10½ inches deep, the flanges being braced together by diagonal channel iron, and radial struts forming the purlins. The purlins are braced beams, so constructed as to stiffen the main ribs laterally. The whole of the roof is braced horizontally, to resist any strain that may be caused by the pressure of the wind either on the gable or on the side. The apex of the roof is covered with glass ridge and

furrow skylight, 152 feet wide, extending nearly the entire length of the roof, and each gutter of the skylight has a snow grating along its whole length, with cross strips to enable the workmen to repair and paint the skylight, when required. The part of the roof below the skylight is covered with boarding and slates. To take off the thrust of the ribs, they are connected across below the rails by wrought-iron beams resting on pillars. The weight of iron in this roof is about 1,100 tons. The roof of the Great Northern Railway station is formed with a circular plank arch on Colonel Emy's plan. [ROOF.] That of the Charing Cross station is also circular, but iron of 180 feet span. The roof of the Lime Street station at Liverpool is of iron of 152 feet span, and that of the station at Birmingham is 864 feet long, and at one end 212 feet span, the width at the other end being slightly less. The Broad Street station of the North London Railway is one of the most successful examples of stations in this country. In roofs constructed with trussed principals, provision is usually made to allow of the expansion of the metal. But in arched roofs this is not so necessary, although rollers, or other expedients for permitting expansion, are usually introduced.

In the Cannon Street station of the Metropolitan District Railway, designed by Mr. Hawkshaw, the total length is 675 feet, and the breadth 201 feet 8 inches, covered by an arched roof of a single span. There are 20 trussed principals, placed 33 feet 6 inches apart, except where the station crosses Thames Street, where they are 35 feet apart. The clear span between the bed plates on the opposite walls is 190 feet 4½ inches. The height from the rails to the springing is 46 feet; from springing to upper side of rib 60 feet; and from upper side of rib to ridge of central skylight 9 feet; making a total height of 115 feet. Each principal is 1 foot 9 inches deep, and 1 foot 2 inches across the bottom flanges. The web is ⅜ thick, and the connecting angle irons are 3 inches by 3 inches by ½ inch. The rib is curved with a radius of 108 feet ⅞ inch, which gives a versed sine of 60 feet. It is trussed at eight points, with vertical struts tied together at the bottom, and braced diagonally. The struts are made of two wrought-iron plates, 10 inches by ½ inch each, stiffened on the outside by T irons 6 inches by 3 inches by ½ inch, and kept asunder by cast-iron distance pieces. The diagonal bracing consists of flat bars 6 inches by ¾ inch at the centre, and 6 inches by 1 inch at the springing. The ends of the main ribs rest on cast-iron bed plates, one bearing being fixed and the other moving on rollers, so as to permit expansion and contraction, and thus take all strain off the walls. For a width of 10 inches from each end, the rib is made double, and the intermediate space is filled with a casting, which stiffens the rib and gives greater area of bearing surface. Wrought-iron purlins 1 foot 8 inches deep, with upper and lower flanges, formed of angle iron 5 inches by 3 inches by ½ inch, extend along the whole length of the roof, at intervals of 11 feet. Louvres on each side of the skylight provide for ventilation. The roof for 22 feet on each side of the louvre frames is formed of corrugated zinc sheets, laid on plank 1½ inches thick, below which for about 50 feet the roof is of glass, and below that it is covered with slates. The length of the longest vertical strut in the roof is about 27 feet, and of the shortest about 15 feet.

It would exceed the limits of this article to enter into any description of the railway workshops commonly introduced at important terminal stations. But it may be stated generally that the circular form of workshops at one time employed has now been abandoned, and the workshops for the repair and construction of locomotives are now very much like common engine factories. In the Crewe workshops great improvements have been introduced by Mr. Ramsbottom, together with many new machines, among which may be enumerated the rolling mill for rolling the tires of railway wheels out of a perforated disc without a seam, and the duplex steam hammer, in which two hammers are made to move simultaneously in a horizontal plane, so that the mass of iron on the anvil is struck by a hammer on each side at the same time. Most of the woodwork of railway carriages is now made by proper shaping machines to the form required. No good arrangement of sheds has yet been introduced for keeping engines under when the steam is up, and the smoke emitted from the engines rapidly corrodes the iron work of the roof in which such engines are usually placed, while the smoke vomited forth from the doors and other apertures near the ground constitutes a nuisance to the neighbourhood. For getting the steam up in locomotives and for keeping it up, swivelling pipes of sheet iron, like water cranes, should be set at convenient distances apart on each line of rails, which pipes should communicate with a great flue running beneath the floor of the shed from end to end, and communicating with a chimney, in which the velocity of the current of smoke might be maintained by the introduction of a steam jet. Each engine when the fire was kindled would have the swivelling pipe brought over the funnel, so as to take the smoke and transmit it to the great chimney, by which it would be conducted high into the atmosphere, and there dispersed. In some cases the locomotive running sheds, instead of being rectangular, are fan-shaped and sometimes semicircular, with a turn-table for directing the engine upon any one of the radiating lines, but the turn-table is not usually covered. With this arrangement any injury to the turn-table locks all the engines up.

The arrangement of the booking offices in a railway station is an object of considerable importance where a large passenger traffic has to be conducted. Two plans are in common use. In one the offices are set upon the departure platforms, and in the other they are

placed across the ends of the platforms at right angles to the lines of rail. At the Victoria station in Pimlico both plans are in use, the former being adopted for the London, Chatham, and Dover, and the latter for the Brighton traffic. Goods stations should be so placed as to be easily accessible from the neighbouring high roads, and should be so arranged that the goods trains may be run into them direct without uncoupling. The mineral and general goods traffic should be kept distinct, and goods yards should be placed upon a level, and arrangements for shunting without the use of engines should be provided. At the Camden station small capstans driven by shafting are erected at suitable points, and by passing a rope round one of these revolving capstans a train may be moved in any required direction. Hydraulic machinery, for hoists and otherwise, is employed at some stations with satisfactory results. The Great Northern goods shed, which is nearly in the centre of the yard, covers fourteen lines of rails.

Suspension roofs for large spans were advocated by Mr. Hansom about 1840, and more recently by MM. Lehaître and de Mouldésir in a paper read before the Society of Civil Engineers of France in 1866. They estimate that a roof of this character for a circus 100 mètres or 328 feet in diameter with a central column of cast iron, and the covering of zinc No. 14 wire gauge, would not exceed 3*l*. 6*s*. 8*d*. per square yard, or without the central column 3*l*. 2*s*. 6*d*. For rectangular buildings it is proposed to carry the chains by columns placed upon the side bearing walls, those parts of the rafters which are nearest the sides being slung from the chains, while the central portions are supported by struts. The suspension may be effected by steel wire ropes.

Stationary Contact. The curve of intersection of two surfaces which touch each other has in general a double point at the point of contact, the tangents at which are distinct. When these tangents coincide, there is a cusp or stationary point on the curve of intersection, and the contact of the surfaces is then said to be *stationary*. (Salmon's *Analytical Geometry of Three Dimensions*, Dublin 1862.)

Stationary Engine. A form of steam engine for drawing carriages on railways by means of a rope, so called to distinguish it from the locomotive engine, which runs along the railway, drawing the carriages after it. Railway propulsion by means of stationary engines placed along the line for the purpose of drawing the carriages from stage to stage, was at one time contemplated as an alternative system to locomotive propulsion. But the improvements carried out about 1830 in the locomotive removed the chief inducements to the adoption of stationary engines, which are not now employed except as an expedient for enabling a train to ascend very steep inclines. The Ghauts in India, the Sœmmering Alps, and many other mountainous ascents up which railways have been carried, are surmounted by powerful locomotives; and a locomotive has been enabled to pass over Mont Cenis, by constructing the line with a high central rail, the opposite sides of which are bitten by friction wheels driven by the engine. But the railway recently carried over a part of the Andes to Santiago makes use of stationary engines, which draw up the train from stage to stage by ropes. Such ropes should be made of steel wire, and should have numerous swivels in their length to obviate the risk of kinks. There is nothing peculiar in the stationary engine employed for this purpose.

Stationary Point. If a plane curve be conceived to be generated by the motion of a point in a line (the tangent) which itself turns around that point, then a stationary point on the curve will be produced whenever the describing point comes to rest momentarily, previous to changing the direction of its motion in the tangent. A stationary point is sometimes called a *cusp*. It may also be regarded as a *double point* at which the two tangents to the curve coincide. The tangent at a stationary point, therefore, meets the curve in three coincident points; it is termed a *cuspidal tangent*.

Stationary State. A phrase employed by some economists to denote that condition of society which neither progresses nor retrogrades, and in which the accumulation of capital only keeps pace with its destruction or consumption. Such a condition is of course hypothetical; but the expression is intended to indicate that when the rate of profit is low, the disposition to accumulate is weakened; when the rate is high, saving is encouraged. These facts will, however, be exhibited concurrently with the disposition of a community, provided the advance of capital is secured to the lender; for it may be the case that rates of profit are high, while the disposition to accumulate may be neutralised by indifference or by insecurity, or the rate of profit may be very low, while the instincts of the people lead them to economy. The last case may be illustrated by the low rate of profit and the saving habits of the Dutch in the last century.

Stationary Tangent of a Curve. A double tangent at which the points of contact coincide. It meets the curve, therefore, in three consecutive points. The curve being regarded as the envelope of a movable line, the latter will be a stationary tangent whenever, previous to its rotation being reversed, its motion is momentarily arrested. The point of contact of a stationary tangent is called a *point of inflexion*, since the curve there passes from one to the other side of the tangent. The points of inflexion of a curve (together with its double points) all lie on its Hessian.

Stationary Tangent Plane of a Surface. A tangent plane which has stationary contact with the surface. Such a plane may be regarded as a double tangent plane whose points of contact coincide. The point of contact of a stationary tangent plane is called

a *parabolic point*. [INDICATRIX; PARABOLIC POINT.]

Through any point in space there can in general be drawn $4n(n-1)(n-2)$ stationary tangent planes. (Salmon's *Analytical Geometry of Three Dimensions*.)

Stationery. The name given to all the materials employed in the art of writing, but more especially to pens, ink, and paper. The term *stationery* is derived from the business of booksellers having been anciently carried on entirely in stalls, or *stations*. The Stationery Office in London is the medium through which all government offices, both at home and abroad, are supplied with writing materials; and at the same time it contracts for the printing of all reports and other matters laid before the House of Commons, &c. It consists of a comptroller, a storekeeper, and about thirty clerks and other subordinate officers, and has a branch establishment at Dublin.

Statistics. This modern term, which has finally superseded its ancient equivalent *political arithmetic*, is held to include all collections of facts which bear upon social life, and such inferences from these facts as rest on numerical calculations, in special contrast to those which are derived from a real or supposed analysis of the moral nature, or the sympathies, the antipathies, the reason, and the feelings of mankind. The fundamental law in such inferences is, that in particular domains of enquiry comprising these social phenomena, the uncertainty which attaches itself to all induction on the individual action of mankind, and their individual tendencies and liabilities, is eliminated when an aggregate is taken. Thus, for instance, we cannot state certainly that any particular individual will apply himself to the satisfaction of any economical demand, but we may be quite certain that, in a general estimate of society, parties will be found who will engage themselves in such occupations; we cannot assert that any particular individual will die of disease in a given number of years, but we may be certain, if a sufficiently wide basis for inference be taken, and all the facts which might disturb the average be accounted for, that a given number of lives will fall annually out of a thousand inhabitants of all ages, and so on. The essential feature, then, of all statistical inductions is that they are derived from averages, and the necessary caution in all such averages is that they are at the best approximations to physical certainty, for every statistical product is always guarded by a margin of variation. If it were possible to analyse completely the physical, mental, and moral constitution of man, we might be able to deal with individual men as accurately as we can determine the constitution and predict the phenomena of inorganic bodies. But at present organic existence, and in particular those forms of organic existence which are endowed with spontaneity, are not so susceptible of such a scientific analysis as would result in a scientific induction. Statistical methods of inference, therefore, are strictly relative to such phenomena as defy exact analysis, and are provisional, or at least imperfect.

Similarly, statistical enquiry is directed to such physical phenomena as, being relative to man's several instincts and interests, are not yet collected within the verge of exact analysis. For instance, the course of the seasons, and in particular their effects on the supply of food, are matters of most interesting statistical enquiry. The utmost powers which meteorological observations have conferred on mankind in variable climates seem to be the capacity for a somewhat vague prediction as to what the weather will be for the next twenty-four hours, and this in particular when considerable atmospheric changes are imminent. There has yet been no approximation even of the rudest kind to the discovery of a cycle of the seasons. We have not the least means of guessing, with even a shadow of precision, in the month of January what will be the weather in August. But as the gross amount of corn grown on the soil is relative to the amount and distribution of direct solar heat and moisture in the three summer months, and the amount of corn grown has an immediate effect on prices, and an indirect effect on the relations in which this country stands to foreign corn-producing regions, evidence as to the annual crop, and averages over a series of years, are of considerable importance to the trade and resources of a community, and are said to be statistical. A similar obscurity attends any attempt to determine precisely the constitution of the atmosphere, and its freedom from or impregnation by those mysterious molecules by which endemic, epidemic, and sporadic diseases are generated and perpetuated. But statistical enquiry during the local and general prevalence of such phenomena is exceedingly important, generally highly suggestive, and occasionally susceptible of being put into the shape of a rule. Logically, then, the inference of the statistician is the calculus of probability, in which the probability is heightened by the width of the area, and the plurality of the instances or examples from which the inference is attempted.

The earliest statistical calculations—apart from some vague and uncertain guesses as to the currency and population—were made for certain practical purposes, for the granting annuities and effecting insurances, i.e. the first statistics were what is called *vital statistics*. Such calculations illustrate better than anything else the nature of a statistical induction. No one would ever venture to insure only one life at a vast sum, or grant one annuity only, the payment of which would occupy the whole income of the individual or company making the grant. A number—the largest number possible—of small or comparatively small insurances or annuities are negotiated and effected, in order that the element of risk may be eliminated as much as possible. The ordinary duration of human life, as calculated from enquiries, is not, however, adopted in either case; a margin is always left wherewith

to cover risks and avoid such exceptional circumstances as might disturb the probability. But even with this margin, no small nicety is required in making the calculation. In the early days of the actuary's craft, the duration of human life was considerably underrated. As a consequence, a loss was generally incurred on annuities, a gain on insurances.

Physical laws are very seldom developed from statistics, but they are occasionally suggested by them. An excellent illustration of this distinction is to be found in the laws which govern prices. In the very early days of statistical enquiry, Gregory King came to the conclusion that a scarcity in any commodity for which there is a great and permanent demand, raised the price of what was at hand to satisfy demand to a far greater height than the whole quantity would have reached had the demand and supply been in equilibrio. Thus, for instance, if 20 million quarters of wheat are needed as food for a nation, and the price when in equilibrio is 50*s.* the quarter, a scarcity of ten per cent. will not raise the remaining 18 millions to the price of the 20, i.e. to 50 million pounds, but to 60 or more. Here we have a law, depending upon the urgency of a demand for the necessaries of life, suggested no doubt in the first instance by statistical data, but depending on certain facts in the moral and physical nature of man.

Statistical influences are exceedingly liable to fallacy. This contingency is embodied in the cynical maxim that 'there is only one thing falser than facts, that is figures.' Fallacies in statistics, real and apparent, arise from several causes. In the first place, there is, as Bacon observes, an eager tendency of the human mind towards generalities (gestit mens humana exsilire ad magis generalia), and nowhere so constantly as on social and political phenomena. Concurrent with this tendency, if not identical with it, is that of referring phenomena to simple causes when, in fact, they are the products of a complex causation. A dominant cause, or even a dominant point of view, is taken to explain and account for all the facts. But the chief risk which statistical inferences run, is that of admission as to their scientific, or quasi-scientific sufficiency, but of resistance on the ground that qualifying circumstances, or inveterate and repugnant habits, or compensating forces render it necessary that they should be postponed, modified, or disclaimed. No fuller statistical proof could have been given of any rule, than that in vindication of free trade in corn; it was resisted, not from hesitation as to its abstract truth, but because it was averred that the state of society was artificial, one in which existing interests, originally perhaps indefensible, but now vested, had to be maintained, and in which political and social expediency should override economical laws.

Much discredit has fallen on statistics in consequence of the extravagant and undue exaltation which, in the hands of some persons, has been accorded to certain averages. Thus, the attempt to discover a physical law in the annual proportion of suicides is, it can scarcely be doubted, an absurd and illogical dream, an induction as unreal as those ancient acts of simple enumeration which Bacon exposed. The world, so far as has yet been discovered, is not governed or constituted by these numerical quantities, which are at the best fractions more or less precise and determinate, indicating tendencies which, if they were traced or traceable, would forthwith drop the guise of a numerical quantity, because in all natural laws number goes for nothing, one instance being equal in value to a thousand. In general, too, we may apply the canon of utility to all statistical enquiries. Those calculations which tend neither to direct nor to remedial action are merely curious speculations.

Some statistical inferences are of the highest practical value, as, for instance, those which are called *sanitary*. It has been found, for example, that, under ordinary conditions of health, the annual rate of mortality is about seventeen in the thousand. Any considerable excess over this number suggests that there is something wrong, while any slight deficiency indicates the materials for a contrast. So absolute and yet so practical is the rule derived from this simple numerical statement, that it is not too much to ascribe to it all those improvements in lighting, airing, and draining dwelling-houses, which have so characterised the civilisation, and improved the condition of the people in our times. Similar, and not much less important, is the connection which has been traced between high prices of food and pauperism, crime, and bastardy. The co-ordinate rise and fall of averages such as these, though not absolutely conclusive, are very important aids to that inductive method which Bacon called the rule of *travelling instances*, and Mr. Mill has represented under the term of *concomitant variations*. [LOGIC.]

Statistics in foreign countries are generally supplied from the various administrative bureaux, and are, as a rule, exact and exhaustive. In England the collection of statistics is partly the function of government boards (and as far as these can enquire are as good as can be), and, in part, the action of individual observation or research. Thus the customs returns of exports and imports, of shipping, of trade, of railways, are supplied from the Board of Trade; that of the banks and circulation, from the Treasury; that of pauperism, from the Poor Law Board, &c. But some statistics of great importance are as yet withheld, or only grudgingly accorded. Among those which are desiderated are agricultural statistics, the value of which, though overrated perhaps by some economists, has been, on the other hand, underrated by others. It has been said, for instance, that a knowledge of the breadth of corn sown would be of little interest in determining prices or the exigencies of supply, since no one from year to year can decide from such and such an average what is the yield, and still less what is the average

quality of the grain. This, indeed, may be admitted, but the value of the information if procured would yet be great.

As we have stated, the value of statistics consists not so much in their announcing facts, as in their supplying the premisses for calculating an average. But information as to the amount of corn sown, or breadth of arable land in given years, has this value, that it determines the proportion of home growth to the need of foreign importation, and, within certain limits, suggests the extent of the demand for foreign supply. Much more striking, however, is the significance of the evidence which has recently been given as to the amount of cattle, sheep, and pigs kept in England and Wales, and the immediate explanation which this evidence supplies as to the high price of meat. Of almost all countries, England has the lowest amount of animals used for food in proportion to population.

Within the last thirty years, the collection and arrangement of statistics has formed the business of a very important society in London, and of similar societies elsewhere. The Statistical Society of London has made a most important collection of facts bearing upon every branch of social science, and has regularly tabulated the most important objects of trade and finance. Much of the political economy of foreign countries is in effect statistical in character, and has been supported and furthered by government. An exceedingly important international congress is held triennially in some one of the European capitals, the origin of which was suggested by M. Quetelet of Brussels, in which city the first congress was held. The meeting in London (1860) divided statistical research into six sections: judicial, sanitary, industrial, commercial, census, with military and naval statistics; and, lastly, statistical methods and signs. See the report for the fourth session of the International Statistical Congress, and in particular the excellent introduction by Dr. Farr, and the speech of the late Prince Consort; also *Lettres sur la Théorie des Probabilités appliquée aux Sciences Morales et Politiques*, par A. Quetelet.

Statuary. [SCULPTURE.]

Statue (Lat. statua). In Sculpture, a representation in relief in some solid substance—as marble or bronze—or in some apparently solid substance, of a man or other animal. There are various species of statues: 1. Those smaller than nature, or *statuettes*. 2. Those of the same size as nature. 3. Those larger than nature, called *heroic figures*. 4. Those that are several times larger than nature, and are called *colossal*. The first were by the ancients made to represent men and gods generally. The second represented men celebrated for their learning and talents, who had rendered service to the state, and were executed at the public expense. The third were confined to kings, emperors, and heroes. The fourth species consisted of statues of the gods, or of kings and emperors represented under the form of gods. *Equestrian statues* are those in which the figure is seated on a horse. The *Hermæ*, or terminal figures, were pillars surmounted by a head or a bust, according to the deity represented, though the name is derived from that of the god Hermes. Various examples of these figures may be seen in the British Museum. [CHRYSELEPHANTINE; HERMÆ; SCULPTURE.]

Status Quo (Lat.). In Politics, a treaty between two or more belligerents, which leaves each party in possession of the territories, fortresses, &c., which it occupied before hostilities broke out, is said to leave them *in statu quo ante bellum*—in the same state as before the war.

Statute (Lat. statutus, part. of statuo, *I establish*). An Act of Parliament made by the sovereign, by and with the advice of the lords and commons. But some ancient statutes are in the form of charters or ordinances, proceeding from the crown, and in these the consent of the lords and commons is not expressed.

Statutes are divided into *public* and *private*; public Acts being usually defined to be those universal rules which regard the whole community, while private Acts only operate upon particular persons and private concerns. Of private Acts, some are *local*, as affecting particular *places* only; others *personal*, as confined to particular *persons*. Formerly the courts of law were not bound to take judicial notice of a private Act unless it were specially pleaded; and to evade this rule, it became the practice to insert in private Acts a clause declaring them to be public, and binding the courts to take notice of them. It has, however, been provided by stat. 13 & 14 Vict. c. 21, that every new Act is to be taken to be a public Act, and judicially noticed as such, unless the contrary be expressly declared. There is, accordingly, a large class of railway and other *local* Acts, which, though classed with private *bills*, become, when passed, public *Acts*. In private Acts expressly declared *not* to be public Acts, a clause binding the courts to take judicial notice of them is still usually inserted. It will have been seen, however, that the division of statutes into public and private is now chiefly of a formal nature, although in parliamentary practice there are important differences in the manner of passing public and private *bills*, the latter being usually sent as of course for enquiry before a select committee, and being subjected to heavy fees and other expenses, from which the former are exempt. Statutes are also said to be *declaratory* of the law as it stood at their passing; *remedial*, to correct defects in the common law, subdivided into *enlarging* and *restraining*; and *penal*, imposing prohibitions and penalties. But these, again, are rather distinctions of an arbitrary character than of any legal effect, although some legal maxims have been founded on them: e.g. that penal statutes, or clauses in statutes, are to be construed strictly, remedial statutes liberally, &c.

The courts, however, are not, at the present

day, much influenced by general maxims of this nature, except as affording some slight aid to construction in very doubtful cases. Statutes are divided in the statute book, for convenience of reference, into *Public General Acts*, *Local and Personal Acts declared Public*, *Private Acts Printed*, *and Private Acts not Printed*. All the Acts of one session of parliament taken together are said to form properly but one statute, and for this reason an Act of Parliament is always cited as the *chapter* of a particular *statute*, e.g. stat. 29 & 30 Vict. c. 1. Statutes now operate (by stat. 33 Geo. III. c. 13) from the time when they receive the royal assent, unless some other time be fixed for that purpose: the ancient rule was that, in default of any special provision to the contrary, they operated retrospectively from the first day of the session in which they were passed. Every public general Act passed at the present time extends (in the absence of any special provision to the contrary) to the whole of Great Britain and Ireland, exclusive of the Channel Islands and the Isle of Man. With respect to the colonies, the rule is that, in a colony acquired by occupancy, Acts passed before its acquisition come into force immediately upon that event as part of the general law of England, as to all provisions at least not unsuitable to its social circumstances; though it is otherwise in the case of a colony won by conquest or cession, which remains subject to its own pre-existing laws. (1 Steph. *Comm.* 107.) No colony of either class is, in the absence of express provision or necessary implication, affected by Acts of Parliament passed after its acquisition. The sovereign is not bound by any statute, unless named therein.

The growing inconvenience caused by the confusion and multiplicity of the statutes has excited considerable attention of late years. Lord Chancellor Cranworth issued commissions in 1853 and 1854 successively, for the purpose of consolidating the statute law, but these commissions produced little practical result; and the commission of 1854, after sitting for several years, was discontinued abruptly in 1859, owing to the refusal of the House of Commons to vote any further funds for its maintenance. A considerable part of the criminal law was, however, consolidated by a series of statutes passed in 1861. (24 & 25 Vict.) Several statutes, moreover, have been passed of late years for the purpose of expurgating the statute book by the repeal of obsolete Acts, with a view to facilitating the work of a general consolidation. (Stats. 19 & 20 Vict. c. 64; 24 & 25 Vict. c. 101; 26 & 27 Vict. c. 125.)

Statute of Drogheda. [POYNING'S LAW.]

Statute Merchant and **Statute Staple.** These statutes were special forms of bonds or securities for debts, now obsolete. They gave the creditors taking them extraordinary remedies against the body, goods, and lands of the debtor, and were originally permitted only among traders for the benefit of commerce. (Stats. 13 Edw. I.; 27 Edw. III. c. 9; 23 Hen. VIII. c. 6.)

Staurolite (Gr. σταυρός, *a cross*, and λίθος, *stone*). The mineral called *Cross-stone*. [STAUROTIDE.] It is a silicate of alumina with about one-third of the alumina replaced by peroxide of iron, and forms small rhombic prisms (the acute edges of which are frequently replaced), often intersecting and crossing each other at right angles. The most characteristic specimens are from Andreasberg in the Harz, and St. Gotthard in Switzerland; but it is also found in Cornwall and Devon; in Aberdeenshire; and in Wicklow.

Staurolite generally occurs embedded in mica-slate, talc-slate, and clay-slate; sometimes in gneiss.

Staurotide (Gr. σταυρός). A name given by Haüy, and other mineralogists, to the prismatic Garnet, or *Grenatite*. [STAUROLITE.] It occurs in embedded crystals in primary rocks, and is distinguished from Garnet by its crystalline form and infusibility.

Stavesacre. The *Delphinium Staphisagria*. The seeds of this plant are emetic and purgative, owing to the presence of *Delphinia*, a very acrid bitter principle, which, in the dose of a few grains, excites a sense of heat and tingling in various parts of the body. The disease in which it has been chiefly successful is neuralgia, in which it has been applied externally. Stavesacre seeds in the form of ointment or acetous infusion have been used to destroy pediculi.

Stay. A strong rope from the masthead, leading forward and downwards to prevent the spar from falling aft. It takes the name of the mast, as the fore-stay, main-topmast stay, &c. *To stay* means to tack. To be *in stays* is to be in the act of tacking. To *miss stays* signifies to fail in attempting to tack.

Stealer. In Shipbuilding, a short length of plank worked in among the other strakes to facilitate rounding off in parts of great curvature.

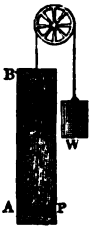
Steam (A.-Sax. stem, Dutch stoom). The elastic fluid into which water is converted by the application of heat.

All liquids whatever, when exposed to a sufficiently high temperature, are converted into vapour. The mechanical properties of vapour are similar to those of gases in general. The property which is most important to be considered, in the case of steam, is the elastic pressure. When a vapour or gas is contained in a close vessel, the inner surface of the vessel will sustain a pressure arising from the *elasticity* of the fluid. This pressure is produced by the mutual repulsion of the particles, which gives them a tendency to fly asunder, and causes the mass of the fluid to exert a force upon the interior surface of any vessel within which it is confined. This pressure is uniformly diffused over every part of the surface of the vessel in which such a fluid is contained; it is to this quality that the mechanical power of steam is due.

To render the chief properties of steam intelligible, it will only be necessary to explain

the phenomena which attend the conversion of water into vapour by the continued application of heat, under the various circumstances of external pressure which present themselves in the processes of nature and art.

Let A B be a tube or cylinder, the magnitude of whose base is a square inch, and let a piston P move steam-tight in it; let it be imagined that under this piston, in the bottom of the cylinder, there is an inch depth of water, which will therefore be in quantity a cubic inch; let the piston be counterbalanced by a weight W acting over a pulley, which shall be sufficient to counterpoise the weight of the piston and its friction in the cylinder; and let the weight W be so arranged that from time to time its amount may be diminished to any required extent. Under the circumstances here supposed, the piston being in contact with the water, and all air being excluded from beneath it, it will be pressed down by the weight of the atmosphere, which we shall assume to be 14¾ lbs. Let it be also supposed that a thermometer is placed in the water under the piston, and that the tube A B is transparent, so that the indications of the thermometer may be observed. The temperature of the water under the piston being reduced to that of melting ice, which is 32° Fahr., let the flame of a lamp be applied under the tube, and let the time of its application be noted. If the thermometer be now observed, it will be seen slowly and gradually to indicate an increasing temperature of the water, the piston maintaining its position in contact with the water unchanged. This augmentation of temperature will continue until the thermometer indicates the temperature of 212°. Let the time be then noted. It will be found that after that epoch, the water will cease to increase in temperature, notwithstanding the continued application of the lamp, the thermometer not rising above 212°. But another effect will begin to be manifested; the piston P will be observed gradually to rise, leaving a space apparently vacant between it and the water. The depth of the water will, however, be at the same time gradually diminished, and the diminution of its depth will be found to bear constantly the same proportion to the ascent of the piston. This proportion will, under the circumstances here supposed, be that of about 1,700 to 1. If the application of the lamp be continued, and the tube have sufficient length, the water will, after the lapse of a certain time, altogether disappear from the bottom of the tube; and when that occurs, the piston will have risen to the height of 1,700 inches, being 1,700 times the original depth of the water.



The tube will now, to all appearance, be empty; but if the apparatus were weighed, it would be found to have the same weight as at the commencement of the experiment. The water, therefore, must still be contained in the tube, though it has assumed an invisible form. To demonstrate its presence, let the lamp be removed; immediately the piston will begin to descend, and the inner surface of the tube will be covered with a dew, which, speedily increasing, will fall to the bottom in drops of water. The piston meanwhile will continue to move downwards, sweeping before it the water from the sides of the tube; and at length will recover its first position, having under it, as at the beginning, a cubic inch of water.

In the above process, the elevation of the piston is produced by the elastic force of the steam into which the water was gradually converted by the lamp. The space between the piston and the water during its ascent, though apparently empty, was filled with steam, which, like air and most other gases, is a colourless and invisible fluid. The proportion of the elevation of the piston to the diminution of the depth of the water being 1,700 to 1, proves that the water in passing into steam increases its volume in that proportion. When the water altogether disappeared, the height of the piston from the bottom of the tube was 1,700 inches; and as the tube under the piston was then filled with the steam into which the water had been converted, it is apparent that the cubic inch of water, in this case, was converted into 1,700 cubic inches of steam.

The pressure of the atmosphere above the piston was, in this instance, overcome by the elastic force of the steam, and the piston, bearing that pressure upon it, was raised to a height of 1,700 inches. In the evaporation, therefore, of this cubic inch of water, a mechanical force has been evolved equivalent to 14¾ lbs. raised to the height of 1,700 inches, or, more exactly, 1,669 inches, according to M. Regnault's determination of the relative volume of steam and water at the atmospheric pressure of 15 lbs. per square inch.

From the moment at which the water began to be converted into steam, the thermometer, having then attained 212°, ceased to rise. Nevertheless, the application of the lamp was continued, and therefore the same quantity of heat per minute was still supplied to the water. Since the water did not increase in temperature, it may be asked what became of this continual supply of heat received from the lamp? It may be said that it was imparted to the steam into which the water was converted; but if the thermometer were raised out of the water, and held in the steam between the water and the piston, it would still indicate the same temperature of 212°. We thus arrive at the fact, that, notwithstanding a large supply of heat imparted to water during its evaporation, heat is sensible neither in the water itself nor in the vapour into which the water is converted.

The quantity of heat which is thus absorbed in converting water into steam is easily determined, the interval of time being noted which elapsed between the first application of the lamp and the moment at which the thermometer ceased to rise. Let us suppose that

interval to be an hour; the interval between the moment when the thermometer ceases to rise and the process of evaporation begins, and the moment at which the last particle of water disappears from the bottom of the tube and the evaporation is completed, will be found to be 5½ hours; and in general, whatever may be the length of time necessary to raise the temperature of the water from 32° to 212°, 5½ times that interval will be necessary for the same source of heat to evaporate the same quantity of water. It follows, therefore, that *to evaporate water under a pressure of* 14¾ *pounds per square inch requires 5½ times as much heat as is necessary and sufficient to raise the same water from* 32° to 212°.

Since the difference between 212° and 32° is 180°, and since 5½ times 180° is 990°, it follows that to convert the water into steam after it has attained the temperature of 212°, as much heat must be supplied to it as would suffice, if it were not evaporated, to raise it 990° higher. The heat thus absorbed in evaporation, and not sensible to the thermometer, is said to be latent in the steam; and the phenomena which have been just described form the foundation of the whole theory of *latent heat*. That this large quantity of heat is actually contained in the steam, though not sensible to the thermometer, admits of easy demonstration, by showing that it may be reproduced by converting the steam into water. If a cubic inch of water, in the form of steam at the temperature of 212°, be introduced into the same vessel with 5½ cubic inches of water at the temperature of 32°, the steam will be immediately converted into water; the temperature of the 5½ inches of ice-cold water will be raised to 212°, and there will be found in the vessel 6½ cubic inches of water at 212°. Thus, while the steam, in reassuming the liquid form, has lost none of its temperature, it has nevertheless given up as much heat as has raised 5½ cubic inches of water from 32° to 212°. It is therefore demonstrated that this quantity of heat was actually in the steam, and that its presence there in the latent state conferred upon the water in the vaporous form the property of elasticity.

We have here supposed that the pressure under which the water in the tube was evaporated was the mean pressure of the atmosphere, or 14¾ lbs. per square inch. Let us now suppose that the piston resting on the water is loaded with a force of 14¾ lbs., besides the pressure of the atmosphere, which may be done by taking 14¾ lbs. from the counterpoise W. If the same process be followed as before, it will now be found that the thermometer will not cease to rise when it has attained 212°; nor will the piston then begin to ascend. The thermometer will, on the other hand, continue to rise until it has attained 250°. It will then, as in the former case, cease to rise; the piston will ascend, and the water will begin to be converted into steam. The proportion, however, between the ascent of the piston and the diminished depth of the water, or, in other words, between the volume of steam produced and the volume of water producing it, instead of being 1,700 to 1, will now be about 900 to 1, being little more than half the former proportion. The force against which the elasticity of the steam, in the present case, acts, is 29½ lbs.; and this force is raised 900 inches by the evaporation of a cubic inch of water. In the former case a force of 14¾ lbs., being half the present force, was raised to 1,700 inches by the evaporation of the same quantity of water, so that in each case the mechanical effect produced is very nearly the same.

If the pressure under which the evaporation is carried on were varied, it would be found that with every increase of pressure the temperature at which the evaporation would commence would be augmented, and that with every diminution of pressure that temperature would be diminished. It would be also found that the volume of steam produced by a cubic inch of water would be less with every increase of pressure under which the evaporation is made; and that the diminution of volume would be nearly, but not in quite so great a proportion, as the increase of pressure. In like manner, if the pressure be diminished, the volume of steam produced by a cubic inch of water will be augmented in nearly, but not quite so great a proportion, as that of the diminution of pressure. From all this, it obviously follows that the mechanical effect evolved by the evaporation of a given volume of water under different pressures is very nearly the same; greater pressures, however, having a slight advantage over lesser ones.

It has been seen that 14¾ lbs. are raised to a height of 1,700 inches by the evaporation of a cubic inch of water under the pressure of 14¾ lbs. per square inch. Now, 1,700 inches are nearly equal to 142 feet; and 14¾ lbs. raised 142 feet is equivalent to 142 times 14¾ lbs. raised one foot, which is equal to very nearly 2,100 lbs. raised one foot. To use round numbers, it may then be stated, that by the evaporation of a cubic inch of water a mechanical force is produced equivalent to a ton weight raised a foot high; and that this force is very nearly the same whatever be the temperature or pressure under which the evaporation takes place.

From what has been above explained, it is apparent that the quantity of sensible heat in steam is augmented with every increase of pressure under which the evaporation is carried on; but if the interval of time be observed which elapses between the first application of the lamp to the ice-cold water in the experiment above described, and the moment at which the last particle of water disappears by evaporation from the bottom of the tube, it will be found that this interval is nearly the same, whatever be the temperature or pressure under which the evaporation takes place. It follows that the actual quantity of heat necessary to convert ice-cold water into steam is nearly the

same, whatever be the pressure of the steam; but as the temperature of steam increases and diminishes as the pressure is increased or diminished, it follows that this given quantity of heat is differently distributed between sensible and latent heat in steam of different pressures. As the pressure is increased the sensible heat is augmented, and the latent heat undergoes a corresponding diminution, and vice versâ. The sum of the sensible and latent heats is, in fact, a constant quantity, or nearly so, the one being always increased at the expense of the other. It has been shown that in converting water at 32° of temperature, and under a pressure of 14¾ lbs. per square inch, into steam, it was necessary first to give it 180° additional sensible heat, and afterwards 990° of latent heat, the total heat imparted to it being 1,170°. The actual temperature to which water would be raised by the heat necessary to evaporate it, if its evaporation could be prevented by confining it in a close vessel, will be found by adding 32° to 1,170°. It may, therefore, be stated that the heat necessary for the evaporation of ice-cold water is as much as would raise it to the temperature of 1,202°, if its evaporation were prevented. If the temperature of red-hot iron be, as is supposed, about 1,200°, and if all bodies become incandescent at the same temperature, it follows that to evaporate water it is necessary to impart to it as much heat as would be sufficient to render it red hot if its evaporation were prevented.

Since water, in passing into steam, undergoes a great enlargement of volume, steam, on the other hand, in being converted into water, undergoes a corresponding diminution of volume. It has been seen that a cubic inch of water, evaporated at the temperature of 212°, swells into 1,700 cubic inches of steam. It follows, therefore, that if a close vessel, containing 1,700 cubic inches of such steam, be exposed to cold sufficient to take from the steam all its latent heat, the steam will be reconverted into water, will shrink into its original dimensions, and will leave the remainder of the vessel a vacuum. This property of steam has supplied the means, in practical mechanics, of obtaining that amount of mechanical power which the properties of the atmosphere confer upon a vacuum. If by any means whatever the space in a cylinder under the piston be rendered a vacuum, the atmospheric pressure will take effect above the piston, and will urge the piston downwards with a force amounting to about 15 lbs. on each square inch on the surface of the piston. To render steam available for this purpose, it is only necessary to inject it into the cylinder until it expels from the cylinder all the atmospheric air or other uncondensable gases which the cylinder contains; and when that is effected, the pure steam which remains in the cylinder being suddenly condensed by the application of cold, leaves the cylinder a vacuum, and gives effect to the atmospheric pressure above the piston, as before explained. This is, in fact, the principle of the atmospheric engine, which is the species of engine which remained in use up to the time of Watt.

In the mechanical operation of steam, which has been already explained, the pressure, density, and temperature of the steam are supposed to remain the same during its action, and the mechanical effect is produced by the continual increase of the quantity of steam produced by evaporation. Thus, the piston in the apparatus represented in the figure is moved upwards, not by any change in the temperature, density, or pressure, but by the increased volume acquired by the continual production of steam. It has been proved that by this process alone the evaporation of a cubic inch of water, whatever be the pressure under which it takes place, evolves a mechanical force equivalent to a ton weight raised a foot high. But if, after this evaporation has been completed, the steam be separated from the water which produced it, and the load on the piston be gradually diminished, the steam will expand by moving the piston upwards in virtue of its excess of pressure, and this expansion will continue until the pressure of the steam shall be reduced to equality with the load on the piston. All mechanical effect developed in this process is due to the steam itself, independently of any further evaporation.

To make this important quality of the expansive action of steam understood, let us suppose the piston loaded with a pressure amounting to four times that of the atmosphere, including that of the atmosphere itself. If the water under the piston be evaporated under this pressure, it will have a temperature of about 292°, and by its evaporation the piston will be raised 40 feet. This will, therefore, be the whole mechanical effect arising from the immediate evaporation of the water. But when the evaporation has been completed, and the piston, with its load of four atmospheres, stands suspended at 40 feet above the bottom of the tube, let a pressure equal to that of one atmosphere be removed from the piston. The remaining pressure of three atmospheres being less than that of the steam below the piston, the piston will be raised, and will continue to rise until it has attained a height of about 50 feet, and the temperature of the steam thus expanded will fall to about 275°; and its pressure being reduced to that of three atmospheres, it will cease to rise. By this process, therefore, a mechanical force has been obtained from the steam equal to the weight of three atmospheres raised 10 feet in addition to the effect obtained by immediate evaporation; but the expansive action does not stop here. Let it be supposed that the piston is again relieved from the pressure of another atmosphere, the superior pressure of three atmospheres below will cause it to rise, and it will ascend to the height of about 75 feet, the temperature of the steam falling to about 250°, and its pressure being reduced to two atmospheres. A further mechanical effect equivalent to the weight of two atmospheres raised to about 25 feet has

thus been obtained; and it is evident that by constantly and gradually diminishing the load on the piston, an additional effect may be always obtained from a given amount of evaporation, to an extent which is only limited by practical circumstances which restrain the application of this expansive principle. Since the cost of producing steam as a mechanical agent depends chiefly on the quantity of fuel necessary to effect the evaporation of a given volume of water, it follows that all the mechanical effect obtained by this principle of expansion is so much power added to the steam without further expense. Its importance, therefore, will be obvious in the economy of steam power. For the manner of rendering it available in steam machinery, see STEAM ENGINE.

The temperature and pressure of steam produced by immediate evaporation, when it has received no heat, save that which it takes from the water, have a fixed relation one to the other. If this relation were known, and expressed by a mathematical formula, the temperature might always be inferred from the pressure, or vice versâ. But physical science has not yet supplied principles by which such a formula can be deduced from any known properties of liquids. In the absence, therefore, of any general relation established by direct reasoning, empirical formulæ have been proposed, which express, with more or less precision, this relation in different parts of the thermometric scale. These formulæ have been so constructed as to give results which nearly agree with the results obtained by experiment. One set of experiments to ascertain the relative bulks of steam and water was made by Watt at an early period of his career, and these experiments were subsequently repeated by his assistant Southern, with great care and skill. Southern's formula for determining the pressure of steam of any given temperature is probably more widely identified than any other with engineering practice, and it gives results sufficiently accurate for engineering purposes. This formula is as follows: If F represent the elastic force of the steam in inches of mercury, and t its corresponding temperature in degrees of Fahrenheit's thermometer,

$$\text{then} \qquad F = \left\{\frac{t + 51{\cdot}3}{135{\cdot}767}\right\}^{5{\cdot}13} + 0{\cdot}1.$$

The numerical process indicated by this formula being somewhat complicated, it may for greater convenience be performed by logarithms, as follows:—

To find the elastic force of steam in inches of mercury by Southern's formula.

Rule.—*To the given temperature in degrees of Fahrenheit's thermometer add* 51·3 *degrees: then from the logarithm of the sum subtract* 2·1327940, *the logarithm of* 135·767. *Multiply the remainder by the index* 5·13, *and to the natural number answering to the sum add the constant fraction* 1-10*th*. *The result will be the elastic force of the steam in inches of mercury.*

One of the most important courses of experiments which have been made upon this subject is that undertaken by a committee of the French Institute, consisting of MM. Prony, Arago, Gerard, and Dulong, in consequence of an application from the French government to the Academy to point out the best means of preventing accidents from the bursting of the boilers of steam engines. The experiments were conducted chiefly by Arago and Dulong, and were certainly not only extremely delicate as to their management, but the most hazardous which science and art owe to the courage and zeal of philosophers. Steam was produced of a sufficient pressure to force a column of mercury up a glass tube to the height of nearly 43 feet; an atmosphere being measured by a column of mercury measuring 29·922 inches. The following table exhibits the temperatures and corresponding pressures of steam, as determined by these experiments, up to fifty atmospheres.

Pressure in Atmospheres	Temperature	Pressure in Atmospheres	Temperature
1	212°	13	380·66°
1½	234	14	386·94
2	250·5	15	392·86
2½	263·8	16	398·48
3	275·2	17	403·83
3½	285	18	408·92
4	293·7	19	413·78
4½	300·3	20	418·46
5	307·5	21	422·96
5½	314·24	22	427·28
6	320·36	23	431·42
6½	326·26	24	435·56
7	331·7	25	439·34
7½	336·86	30	457·16
8	341·78	35	472·73
9	350·78	40	486·59
10	358·88	45	499·14
11	366·85	50	510·6
12	374		

The last six temperatures in the above table are deduced by calculation from the formula

$$e = (1 + 0{\cdot}7153t)^5,$$

in which e expresses the elasticity in atmospheres, and t the temperature in centième degrees, beginning from 100°, and proceeding upwards. The methods employed in this magnificent course of experiments will be found detailed in the *Annales de Chimie et de Physique*, tome xliii. p. 74.

The most recent and trustworthy experiments upon the heat and pressure of steam have been made by M. Regnault in France.

M. Regnault has shown that the total amount of heat existing in a given weight of steam increases with the pressure. Thus, in steam with a pressure of 14·7 lbs. upon the square inch, the sensible heat of the steam is 212°, the latent heat 966·6°, and the sum of the latent and sensible heats 1,178·6°; whereas, in steam of 90 lbs. upon the square inch the sensible heat is 320·2°, the latent heat 891·4°, and the sum of the latent and sensible heats 1,211·6°. There is, therefore, a difference of 33° in the total heat of a pound of water

raised into steam of 14·7 lbs. pressure and that of a pound of water raised into steam of 90 lbs. pressure; so that the high steam if expanded into low will have an excess of temperature beyond that necessary for the maintenance of the vaporous form, or, in other words, will be in the state of surcharged steam. Surcharged steam, or steam to which more heat is imparted than is necessary for the maintenance of the vaporous form, comes under the same physical laws as air and other permanent gases. And with all gases, when the temperature is constant, the pressure varies simply as the density, or inversely as the volume. When the pressure is constant, the dilatation is uniform with uniform additions of heat, and is at the rate of $\frac{1}{490}$ of the volume at 32° for every additional degree of temperature. When the volume is constant, the increase of pressure is $\frac{1}{490}$ of the pressure, at 32° for each additional degree of temperature. In the *Edinburgh New Philosophical Journal* for July 1849, a formula is given by Mr. Rankine, which educes results very nearly corresponding with those which M. Regnault obtained by experiment; and from this formula, therefore, the most material of M. Regnault's results may be obtained. Mr. Rankine assumes a point of temperature t, which is 462·28° of Fahrenheit's scale below the ordinary zero of that scale, as a new *absolute zero*, and he supposes the boiling point of the water to have been adjusted under a pressure of 29·922 inches of mercury; so that 180° of Fahrenheit may be exactly equal to 100° of the centigrade thermometer. The formula is applicable for finding the elasticity of other vapours besides that of water; but three constants, α, β, γ, have to be determined for each fluid by experiment. If P be the pressure of the steam and t the point of absolute zero, as explained above, then the formula for calculating the pressure from the temperature is—

$$\log P = \alpha - \frac{\beta}{t} - \frac{\gamma}{t^2},$$

and the inverse formula for calculating the temperature from the pressure is—

$$\frac{1}{t} = \sqrt{\frac{\alpha - \log P}{\gamma} + \frac{\beta^2}{4\gamma^2}} - \frac{\beta}{2\gamma}.$$

The values of the constants have been derived from M. Regnault's experiments, and they are as follow:—

$$\log \beta = 3{\cdot}4403816\,;\ \log \gamma = 5{\cdot}5926244\,;$$

$$\frac{\beta}{2\gamma} = 0{\cdot}0035189\,;\ \frac{\beta^2}{4\gamma^2} = 0{\cdot}000012364.$$

The value of α, other things being the same, depends upon the measure of elasticity adopted. If it be inches of mercury, the value of α will be 6·426421; if it be pounds avoirdupois on the square inch, the value of α will be 6·117817.

The following table is derived from M. Regnault's experiments, with the addition of a column showing the volume of the steam relatively with the volume of the water from which it is generated, computed by Mr. D. K. Clark, and given in his work on Railway Machinery. In this table we have the total pressure of the steam in lbs. per square inch, its relative volume as compared with that of the water from which it is produced, its temperature, its total heat, or, in other words, the sum of its latent and sensible heats, and finally the weight of a cubic foot of the steam at the several pressures or densities enumerated. The steam is supposed in every case to be saturated with water.

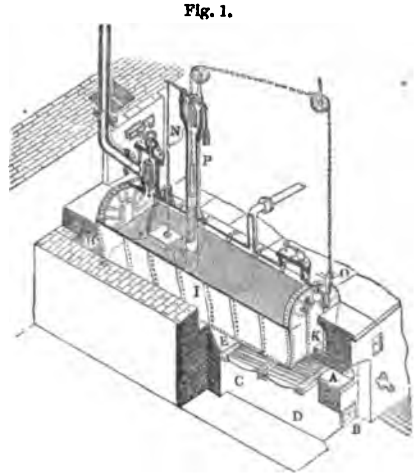
Total Pressure per Square Inch	Relative Volume	Temperature	Total Heat	Weight of One Cubic Foot
lbs.		Fahr.	Fahr.	lbs.
15	1669	213·1	1178·9	·0373
16	1572	216·3	1179·9	·0397
17	1487	219·5	1180·9	·0419
18	1410	222·5	1181·8	·0442
19	1342	225·4	1182·7	·0465
20	1280	228·0	1183·5	·0487
21	1224	230·6	1184·3	·0510
22	1172	233·1	1185·0	·0532
23	1125	235·5	1185·7	·0554
24	1082	237·9	1186·5	·0576
25	1042	240·2	1187·2	·0598
26	1005	242·3	1187·9	·0620
27	971	244·4	1188·5	·0642
28	939	246·4	1189·1	·0664
29	909	248·4	1189·7	·0686
30	881	250·4	1190·3	·0707
31	855	252·2	1190·8	·0729
32	830	254·1	1191·4	·0751
33	807	255·9	1192·0	·0772
34	785	257·6	1192·5	·0794
35	765	259·3	1193·0	·0815
36	745	260·9	1193·5	·0837
37	727	262·6	1194·0	·0858
38	709	264·2	1194·5	·0879
39	693	265·8	1195·0	·0900
40	677	267·3	1195·4	·0921
41	661	268·7	1195·9	·0942
42	647	270·2	1196·3	·0963
43	634	271·6	1196·8	·0983
44	621	273·0	1197·2	·1004
45	608	274·4	1197·6	·1025
46	595	275·8	1198·0	·1046
47	584	277·1	1198·4	·1067
48	573	278·4	1194·8	·1087
49	562	279·7	1199·2	·1108
50	552	281·0	1199·6	·1129
51	542	282·3	1200·0	·1150
52	532	283·5	1200·4	·1171
53	523	284·7	1200·8	·1192
54	514	285·9	1201·1	·1212
55	506	287·1	1201·5	·1232
56	498	288·2	1201·8	·1252
57	490	289·3	1202·2	·1272
58	482	290·4	1202·5	·1292
59	474	291·6	1202·9	·1314
60	467	292·7	1203·2	·1335
61	460	293·8	1203·6	·1356
62	453	294·8	1203·9	·1376
63	447	295·9	1204·2	·1396
64	440	296·9	1204·5	·1416
65	434	298·0	1204·8	·1436
66	428	299·0	1205·1	·1456
67	422	300·0	1205·4	·1477
68	417	300·9	1205·7	·1497
69	411	301·9	1206·0	·1516
70	406	302·9	1206·3	·1535
71	401	303·9	1206·6	·1555
72	396	304·8	1206·9	·1574
73	391	305·7	1207·2	·1595
74	386	306·6	1207·5	·1616
75	381	307·5	1207·8	·1636
76	377	308·4	1208·0	·1656
77	372	309·3	1208·3	·1675
78	368	310·2	1208·6	·1696
79	364	311·1	1208·9	·1716
80	359	312·0	1209·1	·1736

Total Pressure per Square Inch	Relative Volume	Temperature	Total Heat	Weight of One Cubic Foot
lbs.		Fahr.	Fahr.	lbs.
81	355	312·8	1209·4	·1756
82	351	313·6	1209·7	·1776
83	348	314·5	1209·9	·1795
84	344	315·3	1210·1	·1814
85	340	316·1	1210·4	·1833
86	337	316·9	1210·7	·1852
87	333	317·8	1210·9	·1871
88	330	318·6	1211·1	·1891
89	326	319·4	1211·4	·1910
90	323	320·2	1211·6	·1929
91	320	321·0	1211·8	·1950
92	317	321·7	1212·0	·1970
93	313	322·5	1212·3	·1990
94	310	323·3	1212·5	·2010
95	307	324·1	1212·8	·2030
96	305	324·8	1213·0	·2050
97	302	325·6	1213·3	·2070
98	299	326·3	1213·5	·2089
99	296	327·1	1213·7	·2108
100	293	327·8	1213·9	·2127
101	290	328·5	1214·2	·2149
102	288	329·1	1214·4	·2167
103	285	329·9	1214·6	·2184
104	283	330·6	1214·8	·2201
105	281	331·3	1215·0	·2218
106	278	331·9	1215·2	·2230
107	276	332·6	1215·4	·2258
108	273	333·3	1215·6	·2278
109	271	334·0	1215·8	·2298
110	269	334·6	1216·0	·2317
111	267	335·3	1216·2	·2334
112	265	336·0	1216·4	·2351
113	263	336·7	1216·6	·2370
114	261	337·4	1216·8	·2388
115	259	338·0	1217·0	·2406
116	257	338·6	1217·2	·2426
117	255	339·3	1217·4	·2446
118	253	339·9	1217·6	·2465
119	251	340·5	1217·8	·2484
120	249	341·1	1218·0	·2503
121	247	341·8	1218·2	·2524
122	245	342·4	1218·4	·2545
123	243	343·0	1218·6	·2566
124	241	343·6	1218·7	·2587
125	239	344·2	1218·9	·2608
126	238	344·8	1219·1	·2626
127	236	345·4	1219·3	·2644
128	234	346·0	1219·4	·2662
129	232	346·6	1219·6	·2680
130	231	347·2	1219·8	·2698
132	228	348·3	1220·2	·2735
134	225	349·5	1220·6	·2771
136	222	350·6	1220·9	·2807
138	219	351·8	1221·2	·2846
140	216	352·9	1221·5	·2885
142	213	354·0	1221·9	·2922
144	210	355·0	1222·2	·2959
146	208	356·1	1222·5	·2296
148	205	357·2	1222·9	·3033
150	203	358·3	1223·2	·3070
160	191	363·4	1224·8	·3268
170	181	368·2	1225·1	·3443
180	172	372·9	1227·7	·3623
190	164	377·5	1229·1	·3800
200	157	381·7	1230·3	·3970

Steam Boiler. A vessel in which water is converted into steam for the purpose of supplying steam engines, or for any other purposes for which steam is used in the arts, or in domestic economy.

Waggon Boiler.—One of the oldest forms of boiler used for land engines, is that called the *waggon boiler*, an isometric view of which is given in fig. 1; but this boiler has now almost entirely disappeared, owing to its small evaporative power compared with the consumption of fuel, and to its incapacity to resist the pressure of steam which recent discoveries have shown to be necessary for the economical working of the steam engine.

Fig. 1.



The proper level of the water within this boiler is maintained by means of a balanced buoy or float communicating with the rod N, which is attached to a lever set on the top of the stand-pipe P. The top part of this pipe is widened out so as to form a small cistern into which the water for replenishing the boiler is pumped by the engine; and a valve in the bottom of the cistern, when opened by the lever communicating with the rod N as the float subsides from the falling of the water-level, admits a sufficiency of feed water to replace the water removed by evaporation. When there is already a sufficiency of water in the boiler the valve in the feeding cistern remains closed, and the excess of water in such a case runs to waste through an overflow pipe provided for that purpose.

In marine and locomotive boilers the use of a float for regulating the admission of the feed water is inapplicable, and there the attendant has from time to time to adjust a cock in the feed-pipe, so as to admit the proper quantity of water. To enable him to know at what level the water stands within the boiler a succession of cocks, called *gauge-cocks*, is attached to the boiler, rising one above the other; and the highest of these cocks when turned should always let out steam, and the lowest water. A glass tube is also affixed perpendicularly to the outside of the boiler in such a manner, that its upper extremity communicates with the steam within the boiler, and its lower extremity with the water. The water consequently stands in the tube at the same level as in the boiler, and the height of the water in the boiler is thus rendered visible. Cocks are provided at the top and bottom of the tube, so that if the tube happens to be

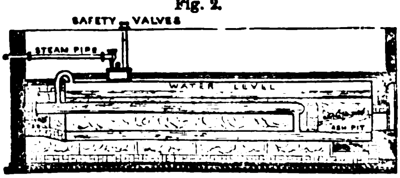
broken, the issue of the steam or water may be prevented.

The draught through the furnace of land boilers is regulated by a plate of metal or *damper*, as it is called, which closes, to a greater or less extent, the opening of the flue, in the manner of a sluice. A damper of this kind is seen at O, and it is counterpoised by a weight in the stand-pipe P, by means of a chain passing over pulleys. When the pressure of the steam in the boiler rises beyond the desired point, the water is forced up by it into the pipe P to a more than usual height. The weight in P being thus floated up, the damper at O preponderates, and partly closes the flue, whereby the intensity of the draught through the furnace is diminished, and less steam is raised. To provide an escape for the superfluous steam, which if suffered to accumulate would burst the boiler, one or more valves, opening upwards and loaded by a weight or spring to a sufficient degree to balance the pressure of the steam, must be applied. This species of valve is called the *safety-valve*, and a valve of this kind is seen in the figure affixed to the top of the boiler near N: a pipe proceeds from the safety-valve, which conducts the waste steam into the atmosphere.

Cylindrical Boilers.—The usual pressure of steam employed in waggon boilers is from 3 to 5 lbs. per square inch. In many engines, however, and especially in those which work expansively, it is found expedient to use steam of a higher pressure. To sustain this pressure waggon boilers are not well adapted, and hence a new class of boilers has been introduced of a cylindrical form, and which are therefore termed *cylindrical boilers*. These boilers can withstand a considerable pressure without danger. Their construction in the subordinate features is very various, but a form much approved is that known as the *Cornish boiler*.

Cornish Boiler.—The boilers used at the mines in Cornwall, have long been celebrated for great economy of fuel and other distinguishing circumstances.

Fig. 2.



A very good example of a Cornish boiler is

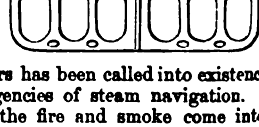
Fig. 3.

represented in figs. 2 and 3; fig. 2 being a longitudinal section of a Cornish boiler, and fig. 3 a transverse section. The furnace is placed, not beneath the boiler, but within it, and the flame and hot air pass through a central flue to the end of the boiler. They next pass along the boiler sides, and finally beneath the boiler bottom, before they escape to the chimney. A brick wall is built at the back end of the fire bars, to form the termination of the furnace. This wall is called the *furnace bridge*. Behind the bridge in some Cornish boilers a pipe containing water extends horizontally within the flue, communicating at the one end with the bottom part of the boiler, and at the other end with the top part of the boiler. The hot air impinging upon this pipe causes the water within it to boil, and a constant circulation of the water is maintained within it. In modern boilers, however, this pipe is omitted. This boiler, like the waggon boiler, is set in brickwork, and it is also covered over with a brick arch, for the purpose of retaining the heat. But a vacant space is left between this brick arch and the top of the boiler for the purpose of enabling the boiler to expand without disturbing the brickwork.

One of the most remarkable peculiarities of the Cornish boilers is the slowness of the combustion in the furnaces, and the large amount of heating surface allowed for the evaporation of the water. Thus, in certain experiments upon Cornish, waggon, and locomotive boilers, recorded in Mr. Bourne's work upon the steam engine, it was found that the number of pounds of fuel burned upon each square foot of fire-grate in the hour was, in the Cornish boiler, 3·46 lbs.; in the waggon boiler, 10·75 lbs.; and in the locomotive boiler, 79·33 lbs. The number of square feet of heating surface of the boiler employed to evaporate a cubic foot of water in the hour was, in the Cornish boiler, 69·58 square feet; in the waggon boiler, 9·96 square feet; and in the locomotive boiler, 6·06 square feet. The number of cubic feet of water evaporated by 112 lbs. of fuel was, in the Cornish boiler, 18·87 lbs.; in the waggon boiler, 13·91 lbs.; and in the locomotive boiler, 11·14 lbs.

Marine Boilers.—Boilers set in brickwork being ineligible in steam vessels, a distinct class

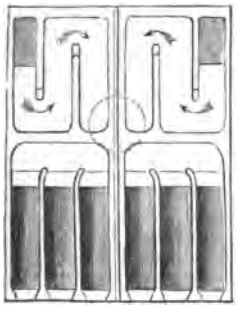
Fig. 4.



of boilers has been called into existence to meet the exigencies of steam navigation. In these boilers the fire and smoke come into contact only with metallic surfaces surrounded by water. Marine boilers consist of a series of large iron vessels, in which are set a number of metallic furnace chambers, connected with metallic flues winding within the boiler, or with a number of short metallic tubes of small diameter which deliver into the chimney.

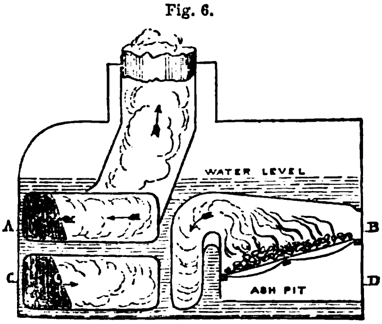
Boilers with large flues winding within them are termed *flue boilers*, and boilers in which the heat is communicated by means of a faggot of small tubular flues passing through the water are called *tubular boilers*. In figs. 4, 5,

Fig. 5.



6, 7, and 8, representations are given of a flue boiler. Fig. 4 is a front elevation of this boiler; fig. 5 a horizontal section through the line A B, seen in fig. 6, and fig. 7 a horizontal section through the line C D, seen in fig. 6. Fig. 6 is a perpendicular section through the line G H, seen in fig. 7. It will be obvious from these figures, that the boiler consists of two portions

Fig. 6.



placed side by side, and each containing three furnaces. The smoke from each group of three furnaces passes into one flue, which winds until it reaches the corner of the boiler, as shown in

Fig. 7.

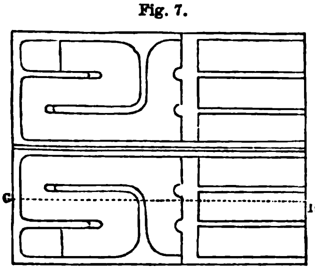
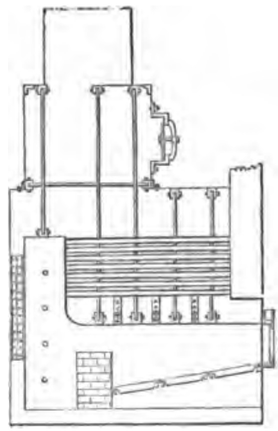


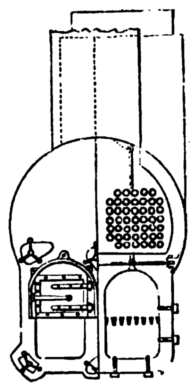
fig. 7. The flue then ascends perpendicularly upwards, and winds in a similar manner through an upper tier of flues until it finally reaches the chimney in the centre of the boiler, represented by the dotted circle in fig. 5.

Fig. 8.



Figs. 8 and 9 are representations of a tubular boiler; fig. 8 being a longitudinal section made perpendicularly through the boiler, and fig. 9 an end view, with one half cut transversely through the furnace and boiler. There are two furnaces in the boiler, and the smoke and flame, after passing over the furnace bridge, ascend into a bundle of small brass tubes, and pass through them on their way to the chimney. Upon the top of the boiler a chest is placed to serve as a receptacle for the steam, which there deposits any particles of water that may happen to be mixed with it. Iron rods pass perpendicularly and horizontally within the boiler to strengthen it, and to enable it to withstand a considerable pressure.

Fig 9.



Nearly all marine tubular boilers are formed on this general type. Sometimes the boiler shell is square instead of waggon-formed, and has more furnaces set within it; but these differences are not very material. Tubular boilers are now very largely employed in steam vessels. They were patented by Mr. Bourne in 1838, but first came into general use about 1844. They are lighter than flue boilers, and occupy less space; and if they are properly constructed they are not difficult to keep in repair.

The consumption of fuel per horse-power in marine boilers is very extravagant, and attempts have recently been made to economise

it by the construction of tubular boilers, in which the water and steam occupy the interior of the tubes, whilst the fire and heated products of combustion are applied to the exterior. By this construction, together with superheating and expansion, the hourly consumption of fuel per actual horse-power has been reduced from 6 lbs. or 7 lbs. to 2 lbs.; but practical difficulties arise in the use of these boilers which have not hitherto been entirely overcome.

Proportions of Marine Boilers.—Marine boilers are commonly proportioned according to the nominal power of the engines which they are employed to drive. But this is not a proper practice. Their dimensions should be determined by the number of cubic feet of water which they are required to evaporate in the hour, and not by the nominal power. To evaporate a cubic foot of water per hour in *flue boilers*, the following are the proper proportions: heating surface, 8 square feet; fire grate, 70 square inches; sectional area of flue, 13 square inches; sectional area of chimney, 6 square inches; area over furnace bridges, 14 square inches; area of flue to area of fire grate, as 1 to 5·4; total heating-surface in feet, divided by the area of flue in feet, $\frac{1}{88}$. To evaporate a cubic foot of water per hour in *tubular boilers*, the following are the proper proportions: heating surface, 9 square feet; fire grate, 70 square inches; sectional area of tubes, 10 square inches; sectional area of back uptake, 12 square inches; sectional area of front uptake, 10 square inches; sectional area of chimney, 7 square inches; ratio of length of tube to diameter, $\frac{1}{28}$ to $\frac{1}{30}$; ratio of length of tube to area of tube, $\frac{1}{13}$ to $\frac{1}{15}$; cubical content of boiler, exclusive of steam chest, 6·5 cubic feet; cubical content of steam chest, 1·5 cubic foot.

The amount of mechanical power producible by a cubic foot of water evaporated per hour by the boiler, depends very much upon the manner in which the steam is used in the engine. In the original engines of Watt, a cubic foot of water evaporated in the hour produced only steam sufficient for one horse-power; but in modern marine engines, which work to some extent on the expansive principle, from $1\frac{1}{4}$ to 2 horse-power are produced by the evaporation of a cubic foot of water per hour—a horse-power being reckoned as equivalent to 33,000 lbs. raised one foot high in the minute.

Incrustation of Marine Boilers.—One of the greatest inconveniences attending the original application of the steam engine to the navigation of the ocean, arose from the gradual accumulation of salt within the boiler in consequence of the necessity of feeding the boiler with salt water from the sea. Sea-water contains about $\frac{1}{33}$ of its weight of saline ingredients; and it is found that when the density of water is increased by evaporation until it contains $\frac{4}{33}$ of its weight of saline ingredients, some of those ingredients begin to be deposited upon the flues, forming upon them a stony crust which retards the transmission of the heat. It is hence very important that the water in marine boilers should never contain more than $\frac{2}{33}$ of salt, and it is easy to keep the water below this point of concentration by blowing out a sufficiency of the over-salted water, and filling up the boiler with the fresher water of the hot well or the sea. Hydrometers are now very generally provided in steam vessels, to enable the engineer to determine the density of the water; and in every case it is right to practise blowing out to such an extent as will prevent the formation of saline or stony incrustations upon the flues. In the case of pressures above 40 lbs., however, sulphate of lime is precipitated from sea water, without any concentration at all, by the mere effect of the high temperature; and surface condensers, which supply fresh water for feeding the boiler, are now very generally employed.

Boiler Explosions.—The explosion of a boiler generally arises from one of two causes: either from the strength of the boiler being inadequate to bear the pressure accidentally or perhaps habitually put upon it, so that it at last gives way; or from the flues having been suffered by an improper subsidence of the water to become red hot, when they cease to be able to sustain the pressure to which they are exposed. A marine boiler may also burst if the water within it be suffered to attain such a point of saturation that salt is deposited to a great thickness upon the flues; for the metal composing the flues, being in such a case unable to transmit the heat to the water with sufficient rapidity, may become red hot, and may thereby lose the strength necessary to withstand the pressure of the steam. Nearly all explosions, however, are traceable either to an undue pressure in the boiler or to a deficiency of water. Sometimes the safety valve becomes deranged when the steam is unable to escape from the boiler. This occurrence will always become discoverable by a reference to the steam gauge, which shows by the position of the mercury the pressure of the steam. And all the gauge cocks should then be opened, and the blow-through valve of the engine should also be opened, so as to let the steam escape in that direction. If the flues have become red hot from a deficiency of water, on no account must more water be added; but the pressure of the steam must be *gradually* reduced, and the fires should be immediately raked out. To reduce the pressure of the steam suddenly, would cause a sudden ebullition, which might carry the water over the red-hot flues, and perhaps cause the boiler to explode.

Proper Method of Feeding Furnaces.—The coals should be broken up into small pieces, and sprinkled thinly and evenly over the fire, a little at a time. The fire should be without any holes or uncovered places in it, as the efficacy of the fuel would be greatly diminished

by the cooling effect of the cold air which would thus enter. The absolute thickness of the stratum of incandescent fuel should be regulated to a considerable extent by the quality of the draught through the furnace. If the stratum of coal be thick while the draught is sluggish, the carbonic acid resulting from combustion combines with an additional atom of carbon in passing through the fire, and is converted into carbonic oxide, which carries off a portion of the fuel to waste; whereas if the stratum of coal is thin, while the draught is very rapid, an injurious refrigeration is occasioned by the large excess of air, beyond that necessary for combustion, which passes through the fire. For further information about steam boilers, see *A Treatise on the Steam Engine*, by the Artizan Club; *A Treatise on Steam Boilers*, by R. Armstrong, C.E.; *A Catechism of the Steam Engine*, by J. Bourne, C.E.; and *A Handbook of the Steam Engine*, by J. Bourne, C.E.

Steam Carriage. A carriage, propelled by steam, intended to run on common roads at a considerable rate of speed. Before the great expansion of the railway system had taken place in the ten years succeeding the opening of the Liverpool and Manchester Railway in 1830, many projects were propounded for running steam carriages on common roads, to supersede coaches drawn by horses; and various steam coaches having this object in view were constructed by different persons, of which the coaches of Gurney, Hancock, Ogle and Summers, and Scott Russell, obtained the greatest notoriety. But as it could not be hoped that a steam coach on a common road could run as fast, or draw such heavy loads, as a locomotive on a railway, and as railways were now extending throughout the country, the inducement for the adoption of steam coaches was taken away, and they were consequently abandoned. This result, however, is merely accidental to the simultaneous extension of the railway system, and constitutes no reason why steam coaches on the common road should not be adopted in countries where railways do not exist, or have received but little developement. The mechanical features of the steam carriages of different constructors were very different, especially in the construction of the boiler. Gurney's boiler was composed of circuits of tubes, placed side by side and filled with water, and the tubes opened into a vessel called the *separator*, where the steam was disengaged from the water. This boiler was very bad. Hancock's boiler consisted of an arrangement of narrow vertical water spaces, alternated by narrow vertical flues through which the heat ascended; and Ogle and Summers' boilers consisted of a number of vertical tubes, which were heated by the fire, and within each of which there was an internal tube to permit the water to descend while the water and steam ascended through the intervening annulus, as in the boiler known as Field's boiler. [STEAM FIRE ENGINE.] In most cases, the cylinders of the steam carriages were horizontal, and the connecting rod turned round the wheel as in locomotives. The only species of steam vehicle now used on common roads, is a kind of steam waggon called a TRACTION ENGINE.

Steam Chest. A chest or box placed on the top of marine boilers to serve as a receptacle or reservoir for the steam.

Steam Coal. A variety of coal intermediate between bituminous coal and anthracite, burning with a good flame and lasting for a long time without being consumed. Excellent steam coals are obtained both from the Newcastle coal field, chiefly the northern beds, and from South Wales, and enormous quantities are consumed and exported from both localities. It is essential for ocean-bound steamers that they should have a coal of this kind which is free from pyrites. Such coals are found generally in certain parts of a coal-field, and are not characteristic of an entire district. The powder and dust of some kinds of coal are capable of being worked up into an admirable artificial fuel of this kind, which possesses the advantage of packing more closely. Hitherto, however, it has not been found possible to make a good artificial fuel that shall stand exposure to the tropics without risk of spontaneous combustion. [COAL.]

Average Value of Coals for the Generation of Steam.—The following table, taken from *Reports on Coals suited to the Steam Navy*, by Sir H. de la Bèche and Dr. Lyon Playfair, shows the average value of coals from different localities:—

Locality	Evaporating Power, or Number of Lbs. of Water evaporated from 212° by 1 Lb. of Coal	Rate of Evaporation, or Number of Lbs. evaporated per Hour	Weight in Lbs. of one Cubic Foot of Coal as used for Fuel	Space occupied by one Ton in Cubic Feet	Cohesive Power of Coals, or Per-centage of large Coals after loading and unloading	Per-centage Amount of Sulphur in Coals
Wales	9·05	448·2	53·1	42·71	60·9	1·42
Newcastle . . .	8·37	411·1	49·8	45·3	67·5	0·94
Lancashire . . .	7·94	447·6	49·7	45·15	73·5	1·42
Scotland . . .	7·70	431·4	50·0	49·99	73·4	1·45
Derbyshire . .	7·58	432·7	47·2	47·45	80·9	1·01

Steam Cultivation. After years of expensive labour and experiment, steam power has been successfully applied to the cultivation of land. The two principal methods in vogue are those of William Smith of Woolstone, Buckinghamshire, who has for many years cultivated his own farm by steam power, and the late John Fowler of Leeds, whose untimely death occurred just as he had perfected his machinery and seen it in successful operation all over the country. Mr. Smith's plan, which has been adopted by Messrs. Howard of Bedford, and several other manufacturers of agricultural machinery, requires the use of one of the ordinary locomotive agricultural steam engines. This is planted in a corner of the field to be cultivated, and there works a double windlass, off one cylinder of which a wire rope is delivered while its farther end is being coiled upon the other. This rope is taken round the field guided by *snatch-block* pulleys at the angles, and lies along the furrow in which the cultivating tool, placed as it were a link in it, is working. The tool, whether a grubber or a plough, is thus drawn to and fro across the field from one side of it to the other, and the pulleys anchored at each end of the furrow are shifted backwards step by step as the work proceeds. As the tool gets over the untilled land lying between it and the engine, the shortening rope is coiled upon the windlass, only so much being at any time let out and used as is required.

The cost of labour is rather greater on this plan than on the other; two men being constantly required at the ends of the working furrow in shifting the anchored pulley blocks around which the rope works. In Mr. Fowler's plan, these men are not needed. The engine travels along the headland, and a self-travelling anchor works along the other headland, while the wire rope employed to draw the tool to and fro between them works around the large horizontal pulleys carried by each. The tool is either a framework of ploughs turning three or four furrow slices together, or a large cultivator, and instead of turning at the land's end as Smith's cultivator needs to do, a double tool is balanced over a pair of wheels, and the two ends come into operation alternately. Messrs. Howard employ both ploughs and cultivators, in which a similar result is obtained in a somewhat different manner. Fowler's method is modified in some cases by the employment of double engines, one at each end of the furrow along which the tool is drawn; and a single rope being wound up alternately on the windlasses beneath these engines draws the plough or cultivator to and fro as each engine in its turn is set agoing.

The advantage of steam cultivation over that by horses lies mainly in the avoidance of that trampling by draught animals which to a great extent destroys the tillage. A cultivator is drawn to and fro on large wheels, and the tilth effected by it is obtained with hardly any drawback. There is, further, the power of accomplishing large quantities of work while the soil is in the fittest condition. In ordinary horse-power cultivation of clay lands, expensive teams have to be kept throughout the year for the sake of their services during the two or three months when alone clay land is in the right state for cultivation. On such land, therefore, a steam engine, which is inexpensive except when actually at work, is on every ground preferable to horse-power for the accomplishment of all tillage operations.

Steam Engine. A machine in which the mechanical power developed in the evaporation of water is rendered available as a moving power. Steam engines vary much in magnitude, form, and proportions, as well as in the details of the machinery by which the power of the steam is adapted as a prime mover. The forms of steam engine, and the mode of its application to transport by land and water, have been consigned to separate articles. [LOCOMOTIVE ENGINE; RAILROADS; STEAM NAVIGATION; TRACTION ENGINE.]

History of the Steam Engine.—Various attempts at the mechanical application of steam on a small scale were made at very early periods in the history of mechanical science. Hero of Alexandria has left a description of a small machine, in which a motion of continued rotation was imparted to an axis by the reaction of steam issuing from lateral orifices in arms placed at right angles to the revolving axis. The date of this invention is about a century before the birth of Christ. Branca, an Italian engineer, about the beginning of the seventeenth century, proposed to give motion to a wheel by a blast of steam blown tangentially against it; and about the same period, De Caus, a French engineer, described a machine by which a column of water might be raised by the pressure of steam confined in a vessel above the water to be elevated. But in the descriptions developements which these projectors have left, there is nothing to demonstrate that they were acquainted with those physical properties of elasticity and condensation [STEAM] on which all the power of steam, as a mechanical agent, depends. In the middle of the seventeenth century, or somewhat later, the celebrated marquis of Worcester published, in his work called *A Century of Inventions*, a description of a steam engine to be worked by steam of high pressure, which, though not minute and explicit in its details, is still such as it is difficult to conceive being written by anyone unacquainted with the elastic force of steam. Towards the close of that century, Papin, a French engineer who was professor of mathematics at Marbourg, directed his attention to the properties of steam, and conceived the idea of obtaining a moving power by introducing a piston into a cylinder and producing a vacuum under it by the gradual condensation of steam by cold. But the steam was also to be generated in the cylinder by the application of a fire; and it was not to be condensed by the application of cold substances to the cylinder, but was to cool gradually of

its own accord. The details of the project were altogether so imperfect as to render it useless in practice. There is no evidence of Papin having carried his idea even so far as the construction of a model until after machines worked by steam had been constructed elsewhere, and he then relinquished his own project in favour of that of Savery.

The first actual working steam engine of which there is any detailed account was constructed by Thomas Savery, an Englishman, to whom a patent was granted for it in the year 1698. Savery reproduced the method of forming a vacuum by the condensation of steam, apparently without being aware of the paper written by Papin. He combined this with the elastic pressure of steam as proposed by Lord Worcester, and constructed an engine, which, for a time, was used to a considerable extent for raising water. Savery's steam engine consisted of a strong copper vessel formed in the shape of an egg, having a tube or pipe at the bottom, which descended to the place from which the water was to be drawn, and another at the top which ascended to the place to which it was to be elevated, and which descended within the oval vessel nearly to the bottom. This oval vessel was filled with steam supplied from a boiler, by which the atmospheric air by which it was previously filled was first blown out of it. When the atmospheric air was thus expelled, and nothing but pure steam was left in the vessel, the communication with the boiler was cut off, and cold water was poured on the external surface of the vessel. The steam within it was thus condensed and a vacuum produced, and the water was drawn up from below in the usual way by suction. The oval steam vessel was thus filled with water; a cock at the top of the lower pipe was then closed, and steam was introduced from the boiler into the oval vessel above the surface of the water. This steam, being of high pressure, forced the water up the ascending tube, from the top of which it was discharged; and the oval vessel being thus again filled with steam, the vacuum was again produced by condensation, and the same process was repeated. By using two oval steam vessels which would act alternately, one drawing water from below, while the other was forcing it upwards, an uninterrupted discharge of water was produced.

Owing to the danger of explosion, from the high pressure of the steam which was used, and from the enormous waste of heat by unnecessary condensation, these engines soon fell into disuse, and an engine was introduced consisting of a cylinder and piston—the piston being connected to one of the ends of a great beam, hung like the beam of a pair of scales, while to the other end of the beam the pump rods of the mine were attached. The cylinder was close at the bottom and open at the top, and when the steam from the boiler was introduced beneath the piston, the pump rods, being heavier than the piston, preponderated, and the piston ascended to the top of the cylinder. The ingress of steam from the boiler was then stopped, and the steam within the cylinder being gradually condensed, the piston descended and made a stroke. This machine was invented by Newcomen, a blacksmith, and Cawley, a glazier, at Dartmouth, in Devonshire. In the first engine constructed by them, the condensation was effected by the affusion of cold water upon the external surface of the cylinder, which was introduced into a hollow casing by which it was surrounded. The discovery of condensation by jet within the cylinder, one of the most important steps in the improvement of the steam engine, was accidental. It happened that a small hole occurred in the bottom of the cylinder of an engine, by which the water let in to cool its external surface oozed in, forming a little jet. The effect was a much more rapid and perfect condensation than ever was or could be effected by external cold. Thenceforward, the method of condensation by jet was adopted, and has ever since been used.

In the early atmospheric engines, the cocks by which the steam was admitted and condensed, and by which the injected water and condensed steam were drawn off, were worked by hand; and as the labour was light and monotonous, and required no skill, boys were employed for the purpose, called *cock boys.* It happened that a cock boy, named Potter, having an itch for play, and endowed with more ingenuity than industry, imagined that by tying strings to the cocks, and connecting them with the working beam above the cylinder, regulating the action by carrying them under or over certain pipes, he could make the beam, as it ascended and descended, open and close the cocks more regularly and effectually than he found himself able to do. This he accordingly accomplished, and was habitually absent from the engine-house, enjoying himself with his playfellows, when his employers were giving him credit for extraordinary industry and regularity in the discharge of his duties. The engine, in fact, by this expedient, nearly tripled its work. Thus, by the ingenuity of a child, the steam engine was first endowed with those qualities of an automaton which have ever since rendered it an object of admiration and interest. The engine, thus endowed with new powers, was subsequently greatly improved in its details by Beighton and by Smeaton. As thus improved, it held its place as the great instrument for the drainage of mines until the epoch which was rendered memorable by the inventions and discoveries of Watt; and it may even still be seen in use at coal mines, and in other situations where coal is cheap. In these early engines the cylinder was open at the top, and the piston was pressed down by the weight of the atmosphere. They were therefore called *atmospheric engines.*

Watt was a mathematical instrument maker in Glasgow. About the year 1763, it happened that the model of an atmospheric engine used at the lectures of Dr. Black, professor of natural philosophy in the university, required some

repairs, and it was accordingly placed in the hands of Watt. In the experiments which it became his duty to make with this model, he was struck with the fact that the quantity of steam consumed for each stroke of the piston was many times more than the contents of the cylinder. The large quantity of water necessary to be injected in order to complete the condensation also excited his surprise. This led him to make experiments, by which he soon arrived at the discovery of some of the most important phenomena connected with the evaporation of water. He made a near approximation to the proportion of the volume of steam to that of water. He ascertained with great precision the latent heat of steam, and consequently determined the quantity of water necessary to condense any given quantity of steam. Filled with astonishment at these results, and more particularly at the nature of latent heat, and at the great amount of the latent heat of steam, he repaired to Dr. Black, and communicated to him the results of his discoveries. He then, for the first time, learned Black's celebrated theory of latent heat, and found that he had himself thus accidentally discovered one of the most striking facts on which that theory rested.

Considering the atmospheric engine in an economical point of view, Watt was forcibly impressed with the waste and expense which appeared to arise in the unnecessary consumption of steam involved in its operation. In the theory of that engine, one cylinderful of steam ought to be sufficient for each stroke of the piston. Watt, on the other hand, found that the actual consumption was at the rate of four or five cylinderfuls per stroke. On examination, he discovered the source of this waste to arise from the fact that, in order to make the piston ascend, it was necessary not only to condense the steam, but to cool the whole mass of the cylinder down to 100°, while to make the piston descend, it was necessary not only to fill the cylinder with steam, but to raise the temperature of the cylinder and piston from 100° to 212°. He soon perceived that this enormous waste of fuel was the inevitable consequence of condensing the steam in the cylinder.

Reflection on these circumstances happily led him to the idea of condensing the steam in a separate vessel, which should be kept immersed in a cistern of cold water, and in which a jet of cold water might be kept constantly playing, with the addition of a pump to draw off the injected water and condensed steam from such vessel. In fact, all the details of the steam engine, as already described, were soon carried into practical effect, and engines constructed according to these principles. Instead of causing the piston to descend by the pressure of the atmosphere, as in the old atmospheric engine, it was forced down in Watt's engines by means of steam, and a lid was applied to the top of the cylinder through a steam-tight hole in which the piston rod passed to connect itself with the working beam.

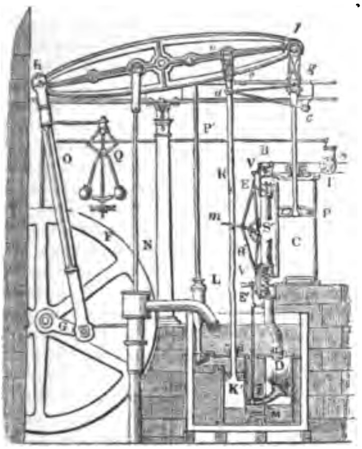
Single-acting Condensing Steam Engine.—When the steam engine is applied to the purpose of pumping water, which in the first periods of its invention was its only practical application, the force which it exerts is required only in raising the pump rods with their load of water, their own weight being more than sufficient for their descent. As the pump rods are attached to the end of a working beam hung upon an axis, the force of the steam is required to draw up that end by drawing down the end at which the steam piston is attached. The steam, therefore, being required only to press the piston downwards, is admitted above the piston, while the space in the cylinder below the piston is kept in free communication with the condenser. The operation of the valves by which the steam is admitted and withdrawn is precisely the same as in the double-acting engine, which will presently be described, and to which reference may be made for a fuller explanation of the action of the machine. When the piston has reached the bottom of the cylinder, the valves for admitting and withdrawing the steam being closed, a valve called the *equilibrium valve* is open, by which a free communication is made between the top and bottom of the cylinder: by this means the steam which fills the upper part of the cylinder, being allowed to flow equally to the lower part, will press with the same force on both sides of the piston, and will therefore have no tendency whatever to move it. Under these circumstances the preponderating weight of the pump rods suspended from the other end of the beam will draw the piston to the top of the cylinder. While it is ascending, the steam which was above will pass through the equilibrium valve below it; and when the piston has reached the top of the cylinder, the cylinder under the piston will be filled with the same steam which previously had driven the piston down. In order to accomplish the next down stroke, the equilibrium valve is closed, and the upper inlet valve and lower outlet valve are opened; the steam pressure acts above the piston, while a vacuum is produced below it, and the piston consequently descends.

Double-acting Condensing Steam Engine.—This species of engine, under some form or other, is that which is almost invariably used as a moving power in all manufactures in this country. One form of it, called a *beam engine*, represented in fig. 1, consists of a cylinder shown in section at C, in which a movable piston P is driven upwards and downwards by the force of steam supplied by a boiler placed near the engine. [STEAM BOILER.]

This piston gives motion to a *working beam* H*f*, which by means of a heavy bar O, called a *connecting rod*, moves a *crank* and *fly-wheel*, from which the machinery to be worked directly receives its motion. Steam is supplied from the boiler to the cylinder by the steam pipe S. The *throttle valve* T in that pipe, near the cylinder, is regulated by a system of levers connected with the *governor* Q. This governor is an apparatus consisting

of two heavy balls, attached to the ends of rods, which are kept revolving on a vertical shaft by a cord or band, or by a train of cogged

Fig. 1.



wheels connected with the fly-wheel. The velocity with which the balls of the governor revolve is therefore always proportional to that of the fly-wheel, and of the machinery driven by it. If, by reason of too rapid a supply of steam, an undue speed be imparted to the fly-wheel, the balls are whirled round with a corresponding velocity; and by reason of their centrifugal force they recede from the vertical spindle round which they turn, and acting thereby on the system of levers which connect them with the throttle valve T, they partially close the latter, check or diminish the supply of steam to the cylinder, and moderate the velocity of the machine. If, on the other hand, the motion of the engine be slower than is requisite, owing to a deficient supply of steam through S, then the balls, not being sufficiently affected by centrifugal force, fall towards the vertical spindle, and acting on the system of levers in the contrary way, turn the throttle valve T more fully open, admitting a more ample supply of steam to the cylinder, so as to increase the speed of the engine to the requisite extent.

The piston P is accurately fitted to the cylinder, and made to move in it steam tight by packing, with which it is surrounded. This piston divides the cylinder into two compartments, between which there is no communication by which steam or any other elastic fluid can pass. A case BB′ placed beside the cylinder contains the valves by means of which the steam which impels the piston is admitted and withdrawn as the piston commences its motion in each direction. The *upper steam box* B is divided into three compartments by two valves; above the upper steam valve V is a compartment communicating with the steam pipe S. Below the exhausting valve E is another compartment communicating with a pipe called the *eduction pipe*, which leads downwards from the cylinder to a vessel called the *condenser*, which we shall presently describe. By this eduction pipe the steam is withdrawn from the cylinder after it has driven the piston. By the valve V a communication may be opened or closed between the boiler and the top of the cylinder, so as to admit or intercept the supply of steam from the one to the other. By the valve E a communication may be opened or closed between the top of the cylinder and the condenser, so that the steam in the top of the cylinder may either be permitted to escape into the condenser or confined in the cylinder. The continuation S′ of the steam pipe leads to the *lower steam box* B′, which like the upper is divided into three compartments by two valves V′ and E. The upper compartment communicates with the steam pipe S′, and the lower with the eduction pipe. By means of the valve V′ steam may be admitted from the steam pipe S′ to the bottom of the cylinder, and by means of the valve E′ this steam may be permitted to escape to the condenser.

The four valves V, E, V′, and E′ are in the engine represented in the figure connected by a system of levers with a single handle or *spanner*, *m*, which being pressed upwards or downwards opens and closes the valves in pairs. Thus, when it is pressed *down*, the levers connected with it raise the upper exhausting valve E and the lower steam valve V′, and close the upper steam valve V and the lower exhausting valve E′. On the other hand, when the spanner *m* is pressed *up*, it opens the upper steam valve V and the lower exhausting valve E′, at the same time closing the upper exhausting valve E and the lower steam valve V′.

The cylinder is closed at the top, and the piston rod P, being accurately turned, runs in a steam-tight collar furnished with a stuffing box, by means of which it is surrounded by a packing of hemp, and constantly lubricated with melted tallow. A funnel is screwed on the top of the cylinder, through which, by opening a stop-cock, melted tallow is permitted to fall from time to time on the piston, so as to lubricate it.

The condenser D is submerged in a cistern of cold water: at its side there enters a tube I′, governed by a cock I, which being opened or closed to any required extent, a jet of cold water may be allowed to play in the condenser. This jet throws the water upwards towards the lower orifice of the eduction pipe L′. From the bottom of the condenser D proceeds a tube having a valve M in it opening outwards; this tube leads to the *air pump* K′, which is a pump submerged in the same cistern with the condenser, worked by a piston having a valve in it opening upwards. The piston rod R of the air pump is carried upwards, and attached at *d* to a system of jointed rods called the *parallel motion*, to which is also attached at *g* the great steam piston-rod. On the rod of the air pump are placed projecting pins, which, as it alter-

nately ascends and descends, strike the spanner *m*, and thereby open and close the valves V, V′, E, E′, in pairs, as already described.

The upper part of the air-pump cylinder communicates by a valve opening outwards with a small cistern K, called the *hot well*, for a reason which will presently appear. A pump L, called the *hot-water pump*, descends into the hot well, and is worked by the great working beam to which its rod is attached.

If the machine thus arranged were worked for any great length of time, the cistern of water in which the condenser and air pump are immersed would become warm, and the condenser would be rendered incapable of doing that for which it is alone useful, viz. of reducing the steam to water *by cold*. To prevent this, a pump N is provided, called the *cold-water pump*, by which a supply of cold water is constantly kept flowing into the cistern, the heated water being at the same time allowed to escape by a waste pipe. The temperature of the water in the cold cistern is thus kept so low as to be capable of effectually condensing the steam.

The piston being supposed to be at the top of the cylinder, the spanner *m* will be raised by the lower pin on the air-pump rod, and the valves V and E′ will be opened, and at the same time the other pair of valves V′ and E will be closed. Steam will therefore be admitted above the piston, and the steam which had previously filled the cylinder below the piston will be drawn off to the condenser. It will there encounter the jet of cold water, which is kept constantly playing there by keeping the cock I sufficiently open. It will thus be immediately reduced to water, or condensed [STEAM], and the cylinder below the piston will remain a vacuum. The steam, therefore, admitted from the steam pipe through the open valve V to the top of the cylinder will press the piston to the bottom of the cylinder. As it approaches that position, the spanner *m* will be struck downwards by the upper pin on the air-pump rod, and the valves V and E′, previously open, will be closed, while the valves V′ and E, previously closed, will be opened. The steam which has just pressed down the piston, and which now fills the cylinder above the piston, will then flow off through the open valve E by the eduction pipe to the condenser, where it will be immediately condensed by the jet of cold water which constantly plays there; and steam from the boiler, admitted through the open valve V′, will fill the cylinder below the piston, and press the piston upwards. When the piston has reached the top of the cylinder, the lower pin on the air-pump rod will have struck the spanner *m* upwards, and will thereby have closed the valves V′ and E, and opened the valves V and E′. The piston will then be in the same situation as at the commencement, and will again descend, and so will continue to be driven upwards and downwards by the steam.

While this process is going on in the cylinder, a quantity of warm water is formed in the condenser, by the mixture of condensed steam with the cold water admitted through the condensing jet I′. It has been shown [STEAM] that any quantity of water in the state of steam, being condensed by cold water, will raise nearly six times its own weight of cold water from the freezing to the boiling point by the latent heat which is rendered sensible in the process of condensation. But since the jet of cold water, instead of being at the temperature of melting ice, is at the common temperature of the atmosphere, say 50°, and it is necessary to reduce the temperature of the condenser to at least 100° (otherwise steam would be produced by it, which would seriously resist the motion of the piston), and to reduce water from 212° to 100° by mixture with water at 50° would require of the latter a quantity equal to about twice the former, it follows that the quantity admitted through the jet must be more than twenty times greater than that which passes through the cylinder in the form of steam.

The warm water thus formed in the condenser, if allowed to accumulate there, would soon choke it up and stop the action of the machine. To prevent this, the air pump is provided; when the air-pump piston ascends, it leaves below it a vacuum, and the *foot valve* M being relieved from all pressure, the weight of the water in the condenser forces it open, and the warm water flows from the condenser into the lower part of the air pump, from which its return to the condenser is prevented by the closed valve. When the air-pump piston descends, its pressure on the liquid under it will force open the valve, through which the warm water will pass; and when the piston descends to the bottom of the pump barrel, the warm water which was below it will pass above it, and cannot return, as the valves which open upwards will be kept closed by its weight. When the piston next ascends, it will raise the water thus collected above it, and will throw it through the valve into the hot well K.

The hot-water pump L is usually a suction and forcing pump, and draws up the warm water from the hot well, driving it through a pipe called the *feed pipe* to a cistern placed over the boiler, from which the boiler derives its feed of water. [STEAM BOILER.]

The system of jointed rods *c d e f g*, called the *parallel motion*, has for its object the maintenance of the rods of the steam piston and air pump in a truly vertical position. The steam piston-rod imparts motion to the beam, and the air-pump rod receives motion from it. But as the beam moves alternately upwards and downwards on an axis, every point on it must move alternately in the arc of a circle whose centre is in the axis of the beam. If, then, the ends of the rods of the steam piston and air pump were attached immediately to the beam, they would move not in truly vertical straight lines, but in the arcs of circles, and by reason of the curvature of such

arcs they would be alternately reflected to the right and to the left. Such an effect would be quite incompatible with that smoothness and precision which are essential to the effective action of the steam engine. By the parallel motion the ends of these piston rods are not immediately attached to the working beam; a rod *c d* called the *radius rod* moves on a fixed centre *c* attached to the framing of the engine; a bar *d b* connects the other end of this radius rod with a pivot *b* on the beam, so that as the beam ascends and descends the pivots *b* and *d* each move in an arc of a circle, and these pivots are thereby drawn aside, but always in contrary directions. These deflections of the ends of the bar *d b* are neutralised at its middle point *e*, which deviates neither to the right nor to the left, but moves in a vertical straight line. To this point *e* the end of the air-pump piston is attached.

At the end of the beam to another joint *f* is attached a bar *f g*, equal to *b d*, connected by pivots with another bar *d g* equal in length to *b f*, so as to form the jointed parallelogram *b d g f*. By this arrangement, as the beam ascends and descends, the point *g* is moved in a manner altogether similar to the point *e*, only that it moves through a greater space in the proportion of the distance of *g* from the axis of the beam to that of *e* from the same point. The point *g*, therefore, to which the steam piston is attached, is moved upwards and downwards in a truly vertical straight line, while the end *f* of the beam with which it is connected is moved upwards and downwards in the arc of a circle.

When the piston is at the top of the cylinder the crank G placed on the axis of the fly-wheel F is at its lowest position, and when the piston is at the bottom of the cylinder it is in its highest position. In each of these positions the action of the steam on the piston could not impart any motion to the crank; for the connecting rod O being then in line with the crank, any force given to it, being necessarily exerted in the direction of its length, would only produce a pressure or strain on the crank pin without the least tendency to turn the crank round the axis of the fly-wheel. In these positions the machine is therefore placed in a dilemma, in which the moving power ceases to have any influence on the object which it is intended to move.

The machine is extricated from this dilemma by the inertia of the fly-wheel. That wheel is a large mass of matter, which, having once received a certain velocity of rotation on its axis, has a tendency to retain such motion, and will, in fact, retain it until it has been deprived of it by the continued resistance of friction and the air. When, therefore, the crank arrives at either of the positions above mentioned, and the moving power ceases to be effective, the inertia of the fly-wheel causes it to continue its motion, and the crank is immediately turned out of the extreme position which it had assumed, and thrown into a position in which the power of the piston on it becomes effective.

The functions of the fly-wheel are, however, not confined to carrying the machine thus through the dead points by the energy of the force received from the piston when the crank was in a more favourable position; it likewise equalises by the same property the unequal effect of the crank. It is only when the crank forms a right angle with the connecting rod that it is fully effective, and as that angle changes, its leverage changes, until at length it is reduced to nothing at those extreme positions just mentioned. When the crank is in and near the position in which it is rectangular to the connecting rod, its action is shared between the fly-wheel and the machinery driven by the engine, a part being engaged in accelerating and therefore giving momentum to the fly-wheel. As it passes towards the dead point, this momentum taken up by the fly-wheel is given back to the crank in aid of the moving power, at those positions of the crank where the effect of the moving power upon it becomes enfeebled. In this manner the fly-wheel in the steam engine becomes a perfect equaliser of the mechanical action of the machine.

To the working end H of the beam is attached the *connecting rod* O, formed of cast iron, the lower end of which is attached to the crank G by a pin. On the axis of the crank is placed the fly-wheel, and connected with its axle is the governor Q already described. The manner in which the crank affects the connecting rod at the dead points produces an effect of great importance in the operation of the engine. When the crank approaches the lowest point of its play, and at the same time the piston is approaching the top of the cylinder, the motion of the crank pin becomes nearly horizontal, and consequently its effect in drawing the connecting rod and the end of the beam downwards, and the piston upwards, is extremely small. The consequence of this is, that as the piston reaches the top of the cylinder its motion becomes very rapidly retarded; and as the motion of the crank pin at its lowest point is actually horizontal, the piston is brought to a state of rest by this gradually retarded motion. A similar effect is produced at the other dead point. The motion of the engine is consequently very smooth, and free from shocks and jerks, the occurrence of which would materially impair its durability and its eligibility as a prime mover.

Such, then, is the engine of Watt. Notwithstanding the manifest advantages attending these improvements, the mining and manufacturing interests were slow and reluctant in adopting them; and, at the end of twenty years from the date of his first improvement, Watt and his partners found that the manufacture of the steam engine, far from being a source of commercial profit,

had entailed upon them a loss of capital to the amount of about 50,000*l*. An application was made to parliament, on this ground, for an extension of the patent, which, after much opposition, was granted till the year 1800. Various improvements in the more minute details of the machinery of the engine succeeded this; and Watt lived to reap an ample reward for his ingenuity and perseverance, and to be acknowledged as one of the greatest benefactors of the human race.

The engine, as applied to drainage and to manufactures, has received no important improvement in its principle since it was dismissed from the hands of Watt. Those principles which he suggested and applied have been carried out to their fullest extent, and the efficiency of the engine has been thus proportionally increased. Modern engines, it is true, as applied to manufacturing purposes, are very different in some of their details from the form of engine just described. For example, the valves, instead of being moved by means of pins or tappets upon the air-pump rod, are now moved by an eccentric; and sliding or sluice valves are now very generally used. Sometimes the beam is discarded altogether, and in the construction of the parts malleable iron is now much more largely employed. But all these modifications merely affect the detail; and anyone who perfectly understands the operation of Watt's engine will have no difficulty in understanding the mode of action of any other variety of engine that has been introduced since his time.

Expansive Engine.—As the operation of the steam engine has been explained, we need only remark that the power which moves the piston is the immediate force with which vapour is produced in the boiler. Each quantity of water which is successively evaporated obtains the space requisite for it in the form of steam, by pressing towards the cylinder an equal quantity of steam previously contained in the boiler; and it is the force with which the steam is thus pressed forward that impels the piston. But it has been shown [STEAM] that great additional mechanical power will be obtained from the steam, if, besides this moving force, which results from immediate evaporation, the expansive power of the steam separated from the water be used. This is accomplished by closing the valve through which steam flows from the boiler to the cylinder before the piston has completed its stroke. Thus, let us suppose that when the piston has advanced through half its stroke the steam valve be closed. The steam which is then acting upon the piston will still urge it forward; but as the piston advances, this steam, assuming a proportionally augmented volume, will acquire a gradually diminished pressure, so that through the remaining half of the stroke the piston will be urged by a pressure progressively decreasing, and at the termination of the stroke it will be a little less than half the force with which the piston was impelled while the steam valve was open.

Since the force of the steam from the moment the steam valve is closed is thus continually diminished, its moving power might be so much attenuated that it would be incapable of overcoming the resistance so as to complete the stroke; this would happen if the steam were cut off when only a small fraction of the stroke has been made, unless the pressure of the steam while the valve is open exceeds the resistance in a proportionate degree. It is for this reason that the expansive principle cannot be brought into operation to any considerable extent, unless steam be used of a greater pressure than is commonly adopted in low-pressure engines. It is also apparent that to produce the same power either a greater volume of cylinder, or greater velocity of motion, must be given when the expansive principle is used.

The mechanism by which the expansive principle is brought into practical operation consists merely in the adaptation of valves or slides which shall stop the admission of steam when the required fraction of the stroke has been made by the piston, but which shall leave the communication with the condenser open till the stroke is completed. If separate valves be used, this is accomplished by adapting the pins or other mechanism by which they are worked to open and close them independently of each other at the proper times. If slides be used, it is effected by regulating the form and movement of the slide, so as to cover and uncover the passages to the cylinder at the proper times. Each species of valve, and each form of slide or cock, has its own peculiar provisions for accomplishing this.

At the time of this invention the steam engine had never been used, except for the purpose of raising water. It became a substitute for horse-power in working pumps. Although Watt perceived, in the first instance, the ease with which it might be adapted as a general moving power, his first efforts were to get it adopted in the mining districts for drainage. His first engines were, accordingly, single-acting or pumping engines; and it was not until the year 1782 that he took a patent for the double-acting engine, the structure and mode of action of which have now been described.

Cornish Engines.—The Cornish pumping engines are for the most part single-action engines. They are constructed of enormous power, and carry out the expansive principle to a great extent. In Cornwall, engines are used for the drainage of mines with cylinders from 7 to 8 feet in diameter, and from 10 to 12 feet stroke. Steam having a pressure of from 20 to 50 lbs. per square inch, and upwards, is used for impelling them, and is cut off at a third, a fourth, and sometimes even at a twelfth, of the stroke. A system of careful inspection has been for some years established by the mining companies, with a view to improving the efficiency of the engines, and

monthly reports of the performance of the engines have been regularly printed. The effect of this has been to stimulate the activity and skill of all concerned in the manufacture and working of these machines, and a marked improvement in them has taken place. The efficiency of these engines is estimated by the number of pounds weight of water which they are capable of elevating one foot high by the combustion of a bushel of coals. This has been termed the *duty* of the engine. In 1769, when Watt first directed his attention to the steam engine, Smeaton computed that the average duty of the engines then in use was about 5½ millions; from that time to the year 1800, a period of thirty years, the duty, owing to the improvements made by Watt, was gradually increased to 20 millions, or very nearly quadrupled. In 1813, the system of inspection just mentioned was commenced, and the average duty was the same as in 1800. From this time to 1826, the engines underwent a progression of slow but steady improvement, and the duty was increased to 30 millions. In 1828, the average duty had risen to nearly 37 millions. The increase since that time has been slower: the average duty for the last few years has been from 60 to 70 millions; but in one well-conducted experiment it was found that by the combustion of a bushel of coals an amount of mechanical power was produced which raised the inconceivable load of 125 million pounds weight one foot high. Thus, by the improvements of Watt and their immediate consequences, the power of the steam engine was, within the space of seventy years, increased about 25 fold. Even this large performance, however, does not exhaust the power resident in the heat produced by the combustion of the coal burnt, and it is now known [THERMODYNAMICS] that even in the best Cornish engines about nine-tenths of the heat is lost without producing any useful effect.

Non-condensing Steam Engines.—The form and structure of non-condensing engines differ from those of double-acting condensing engines only in the absence of the condensing apparatus; i.e. the condenser, the air pump, and the cold-water pump. The steam, after it has impelled the piston, instead of being conducted to a cold vessel to be condensed, is simply allowed to escape into the atmosphere, and is commonly ejected into the chimney of the furnace.

The operation of such a machine is extremely simple. The valves by which the steam is admitted to, and allowed to escape from, the cylinder, are exactly similar to those of the double-acting engine. In the down stroke of the piston, the upper steam valve being open admits steam from the boiler above the piston, and the lower exhausting valve allows the steam below it to escape through a tube into the atmosphere. It is evident that, in such a machine, the piston is always resisted by the pressure of the escaping steam. As such escape cannot be effected except by steam of greater pressure than that of the atmosphere, it follows that the piston is always resisted by a force somewhat greater than the atmospheric pressure. The steam which urges the piston is therefore effective only by the excess of its pressure above that of the escaping steam; and hence the more economical course in non-condensing engines is to employ steam of as high a pressure as may be convenient—the counteracting pressure of the atmosphere being relatively smaller in such a case. All locomotive engines are non-condensing, and the waste steam is invariably projected up the chimney, thus greatly increasing the intensity of the draught.

As the steam used in non-condensing engines must, of necessity, have a pressure considerably exceeding that of the atmosphere, such machines have been generally called *high-pressure engines*; while those which condense the steam have, on the other hand, been called *low-pressure engines*. These terms fail, however, to express correctly the nature of these engines respectively. Many engines in which condensation is used, especially those in which the expansive principle is applied with much effect, are worked with steam of a high pressure, not unfrequently with a pressure amounting to from two to three atmospheres. It is therefore not correct to call such machines low-pressure engines. It is, however, true that engines worked without condensation must, of necessity, be worked by steam of a pressure which is generally called *high pressure*.

Rotatory Steam Engine.—This term is applied to an engine in which a motion of rotation is produced immediately by the action of the steam, without the intervention of such mechanism as the working beam, crank, and fly-wheel. This is usually effected by a piston which, instead of moving longitudinally in the cylinder, revolves within the cylinder on an axis which coincides with the geometrical axis of the cylinder itself. The mechanism is so contrived that this piston shall revolve in steam-tight contact with the sides and ends of the cylinder; and that while steam from the boiler constantly presses it on one side, the steam on the other side shall continually escape to the condenser if it be a condensing engine, or to the chimney if it be a non-condensing engine—a movable division of some kind or other being necessarily interposed between the steam and vacuum to enable this to be done. Most of the contrivances for rotatory engines which have been suggested differ one from the other only in the mechanical expedients by which these ends are attained. Such machines are very numerous and various; but as none of them have yet been found sufficiently advantageous to force them into any use beyond the experimental trials of their inventors, it is sufficient here to have indicated the general principle of their structure.

Marine Engines.—The manner in which the steam engine is rendered an instrument for the propulsion of vessels must, in its general

features, be so familiar to everyone as to require but short explanation. In the case of paddle vessels, a shaft is carried across the vessel, being continued on either side beyond the sides; to the extremities of this shaft, on the outside of the vessel, are attached a pair of wheels, constructed like under-shot water wheels, having a number of flat boards called *paddle boards* fixed upon their rims. As the wheels revolve, these paddle boards strike the water, driving it in a direction contrary to that in which it is intended that the vessel shall be propelled. The moving force imparted to the water thus driven backwards, by reaction on the vessel propels it. On the paddle shaft are fixed two cranks, placed at right angles one to the other, so that whenever one of them is thrown into the highest or lowest position the other is horizontal. These cranks are worked by strong iron rods called *connecting rods*, which are themselves either driven directly by the pistons of two steam engines, or are worked by beams moved by those pistons. Thus the medium of working becomes similar to that used in the ordinary land engines. The two cranks being placed at right angles, it follows that when one piston is at top or bottom of its stroke, and the crank is driven by it into the highest or lowest position, the other will be at the middle of its stroke, and the crank driven by it will be in the horizontal position. One of the pistons is therefore always in a position to produce the most advantageous effect on the crank at the moment that the other piston loses all power over the crank driven by it; and in the same manner it may be seen that while the power of one piston is augmented from zero to its greatest effect, the power of the other is decreasing from its greatest effect to zero. Thus the combined action of the two pistons is nearly uniform in its efficiency. If one engine only were used the motion of the wheels would be unequal, being most rapid when the piston is at the middle of the stroke, and slowest at the extremities. Nevertheless, single engines are sometimes used in paddle vessels with good effect. In the case of screw vessels, the action of the engines is similar, but the propelling shaft runs fore and aft above the keel, and protrudes at the stern, where a great screw propeller is hung upon it. [SCREW PROPELLER.]

The steam engines used for navigation may be either condensing engines or non-condensing engines. If the latter are employed, steam must be used having a pressure above the atmosphere of from 50 to 80 lbs. per square inch. Boilers in which steam is produced under this pressure are considered in Europe so unsafe, that non-condensing engines with low-pressure boilers are almost universally used for navigation. In America, however, high-pressure boilers with non-condensing engines are extensively used on some of the rivers.

The arrangement of the parts of marine engines is different in several respects from land engines. Steam vessels being generally employed to navigate the open seas, and being, therefore, subject to the vicissitudes of tempestuous weather, the machinery must be protected by being placed below the deck. The space allotted to it being thus limited, great compactness is necessary. In paddle vessels, the paddle shaft being very little below the deck, the working beam and connecting rod could not be placed so conveniently above it. If a beam engine, therefore, be employed, two beams are so placed that one comes on each side of the cylinder, and is driven by the piston by means of a cross head attached to the piston rod, from the ends of which rods, called *side rods*, are carried downwards to the ends of the beams. From the other ends of the beams the connecting rod is presented upwards towards the crank. In screw vessels the engines are mostly made with the cylinders horizontal, or if vertical they are usually inverted, and work down to cranks on the screw shaft. [SCREW PROPELLER.]

Side-Lever Engines.—One form of marine engine formerly in the most extensive use, and still employed in many paddle vessels, is the side-lever engine. But the oscillating engine has nearly superseded it. The general arrangement of the parts of a side-lever engine will be easily understood by reference to fig. 2, in which is represented in section a side-lever marine engine with a flue boiler, as placed in a steam vessel. The sleepers supporting the engine are represented at X, and the base of the engine is secured to these by bolts passing through them. S is the steam pipe leading from the steam chest in the boiler to the slides *c*, by which it is admitted to the top and bottom of the cylinder. The condenser is represented at B, and the air pump at E. The hot well is seen at F, from which the feed is taken from the boiler. L is the piston rod connected with the beam H, working on a centre K, near the base of the engine. The other end of the beam H drives the connecting rod M, which extends upwards to the crank, which it works upon the paddle shaft O; *a a* are the rods of the parallel motion. The framing by which the engine is supported is represented at Q R.

The beam exhibited in the figure is shown in dotted lines, as being on the farther side of the engine. A similar beam, similarly placed, and moving on the same centre, must be understood to be at this side, connected with the cross head of the piston in like manner by a parallel motion, and with a cross tail attached to the lower end of the connecting rod and to the opposite beam. The eccentric which works the slides is placed upon the paddle shaft O: and the connecting arm which drives the slides may be easily detached when the engine requires to be stopped. The section of the boiler grate and flues is represented at W U. The safety valve *y* is enclosed beneath a pipe carried up beside the chimney, and is inaccessible to the engine-man. The cocks for blowing out the salt water from the boiler (a process explained under the head STEAM BOILER) are represented at *h*, and the feed pipe at I.

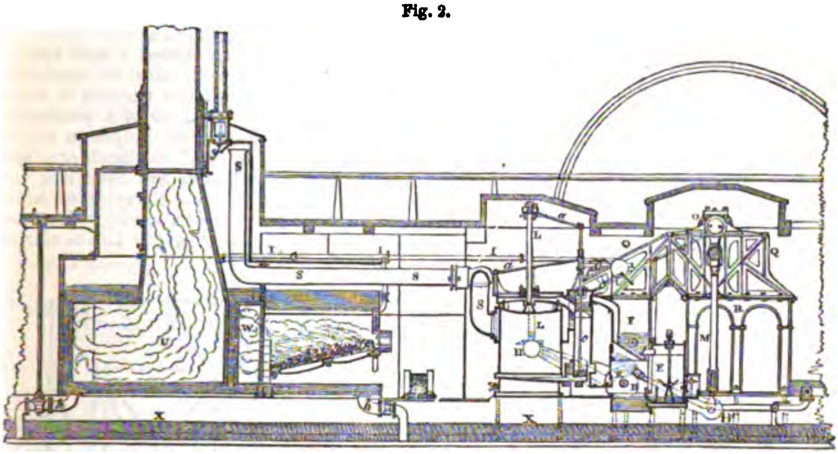
The nature and operation of the several parts

just mentioned will be understood by reference to the explanation of the structure and operation of the double-acting land engine, for, in fact, the marine engine, as here represented, is nothing more than a double-acting condensing steam engine, adapted in its form to the circumstances in which it is used in navigation.

Since, however, the double-acting land engine, which has been described, is not provided with a slide valve worked by an eccentric, it will be proper to explain the form and mode of action of those important parts of the machine.

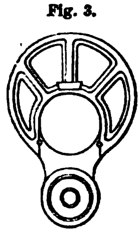
An eccentric is a disc of metal perforated with a hole for the reception of the crank shaft; but this hole is not in the middle of the disc. The edge of the disc is encircled by a ring of brass, from which a rod proceeds to the connections of the slide valve, and it will be obvious that by the revolution of the shaft this rod will be drawn backwards and forwards, in

Fig. 2.



the same manner as if it were connected with a crank in the shaft. An eccentric, indeed, is virtually a short crank with a very large crank pin; and a crank of the same length as the distance from the centre of the shaft to the centre of the disc which constitutes the eccentric would give precisely the motion imparted by the eccentric itself. One form of eccentric employed in steam vessels is represented in fig. 3. A balance-weight is applied opposite to the heavy part of the eccentric, in order that the eccentric may stand in any position on the shaft; and a projecting piece of metal is fixed upon the shaft, which, when it comes in contact with a similar piece of metal upon the eccentric, carries the eccentric round with the shaft. If it should be necessary to reverse the engine, there is another piece of metal upon the opposite side of the shaft, which also comes into contact with the stop upon the eccentric, and the projecting side of the eccentric then stands upon the opposite side of the shaft, as it must in order to communicate a reverse motion to the valve. In modern engines two eccentrics with a link connecting the ends of the two eccentric rods are commonly used for giving motion to each valve. One of these eccentrics is set for moving ahead and the other

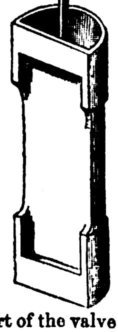
Fig. 3.



for moving astern, and by moving the link endways the valve is made to partake of the motion of that eccentric which is contiguous to it. By this apparatus the engine may be started, stopped, or reversed merely by shifting the position of the link with reference to the valve rod.

The species of valve usually employed in side-lever marine engines is the D valve, so called because it is half a cylinder, and its cross section therefore resembles the letter D. Of this species of valve there are two varieties, the long D and the short D. In the long D the waste steam escapes from one of the ports of the cylinder through the centre of the valve. In the short D there is no central passage in the valve, but the valve consists of two short and closed portions connected together by one or more rods. The long D valve has been most generally adopted. A valve of this kind is represented in fig. 4. The flat projecting part of the valve moves upon similar flat parts on the front of the cylinder, and when the valve is in the middle of its stroke the flat projecting portions accurately close the ports or passages by which the steam enters and leaves the cylinder. The round part of the valve opposite to each cylinder port is made tight by the application of a hemp packing, placed in the

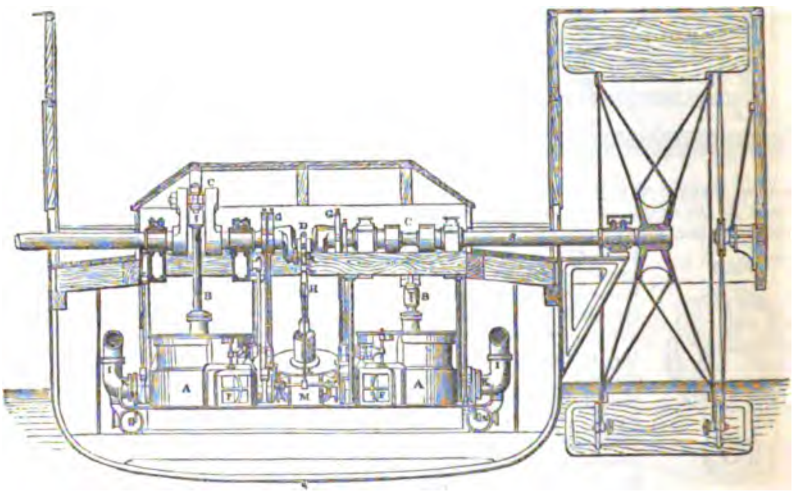
Fig. 4.



casing by which the valve is surrounded; and between the upper and lower packing steam is admitted to circulate round the valve—the steam pipe from the boiler having its debouche in the valve casing. If now the valve be in its middle position, so as to cover accurately both of the cylinder ports, it will be clear that if it be drawn upwards steam will be allowed to enter from the valve casing above the piston; and at the same time any steam or vapour will be allowed to escape from beneath the piston into the central part of the valve, which communicates with the condenser by means of a pipe penetrating the valve casing, either above the upper packing or beneath the lower packing. If the valve be forced below its middle position, the contrary operation will be produced. By moving the valve up and down, therefore, which is done by the eccentric, the piston is pressed up and down in the cylinder in the manner required.

Oscillating Engine.—Side-lever engines occupy an inconvenient amount of space in steam vessels, and also exhibit a needless complication of parts. The strain has to be transmitted not merely through the piston rod and crank shaft, but also through the cross head and cross tail, side rods and connecting rod, and the side levers or beams. This multiplication of the moving parts obviously increases the risk of fracture, and the side levers themselves are peculiarly susceptible of accident from this cause, since by the properties of a lever of this class, the stress or strain upon the beam at the main centre or pivot is twice as great as the strain upon the piston. These defects of the side lever engine have caused a new species of engine to be introduced, called the *oscillating engine*, because the cylinder vibrates or oscillates somewhat in the manner of a pendulum. In this engine the top of the piston rod is coupled immediately with the crank pin, and as the piston rod moves up and down in a line coincident with the axis of the cylinder, while the crank pin revolves in a circle, it is necessary that the cylinder should be able to vibrate

Fig. 5.

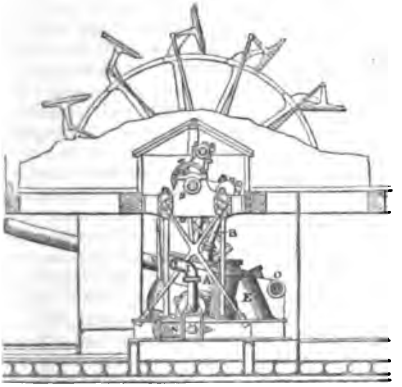


laterally, to enable the motions of the piston rod and crank pin to be reconciled with one another. The cylinder is consequently provided on each side with a short hollow pivot, or trunnion, on which it swings: and through one of these trunnions the steam enters the cylinder from the boiler, while through the other the steam escapes from the cylinder to the condenser. The alternate introduction of the steam above and below the piston is governed by a slide valve attached to the cylinder, and swinging with it; or, in large engines, two valves may be employed for this purpose, and by their suitable attachment to the cylinder they will balance one another.

In steam vessels in which oscillating engines are employed, the cylinders are set immediately beneath the cranks, and the engines occupy but little more in the length of the vessel than the diameter of the cylinder. In the shaft which connects the engines together, and which is called the *intermediate shaft*, a crank is forged, and this crank in its revolution gives motion to the pistons of one or more air pumps. The general nature of the arrangements at present employed in vessels of the most improved class, will be readily understood by a reference to fig. 5, which is a transverse section of the steam yacht Peterhoff, constructed for the emperor of Russia by Messrs. Rennie; and to fig. 6, which is a side view of the engines of the same vessel. A A are the cylinders; B B are the piston rods which are connected immediately with the cranks C C; D is a crank in the intermediate shaft, for working the piston bucket of the air pump E; F F are the slide valves

by which the admission of the steam to the cylinders is regulated; G G are double eccentrics on the intermediate shaft, whereby the valves F F are moved. The purpose of the double eccentrics is to enable the link motion to be employed. H is a handle by which the engines may be stopped, started, or reversed. I I are the steam pipes leading to the steam trunnions K K, on which, and on other trunnions connected with the pipe M, the cylinders oscillate. N N are pumps, the pistons of which are attached to the trunnions, and are worked by the oscillation of the cylinders. O is the

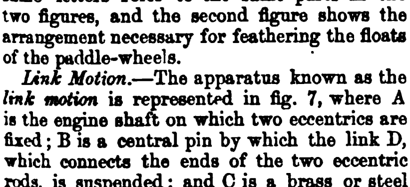
Fig. 6.



waste-water pipe, through which the water which has accomplished the function of condensing the steam is ejected overboard. The same letters refer to the same parts in the two figures, and the second figure shows the arrangement necessary for feathering the floats of the paddle-wheels.

Link Motion.—The apparatus known as the *link motion* is represented in fig. 7, where A is the engine shaft on which two eccentrics are fixed; B is a central pin by which the link D, which connects the ends of the two eccentric rods, is suspended; and C is a brass or steel block which may be moved freely from end to end of the slot in the link D. The centre of this block carries a pin which connects with

Fig. 7.



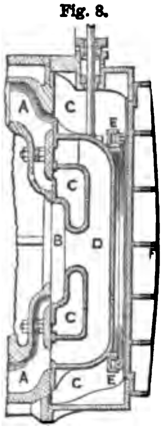
Link Motion.

the valve rod of the engine, and by raising or depressing the link, which is done by means of a suitable rod attached at the point B, the end either of the upper or lower eccentric rod is brought opposite to C, and imparts to the valve the motion of the eccentric to which the block C is opposite. If the link be raised only enough to bring the block C to the middle of the link, there will be no motion imparted to the valve, and the engine will therefore stop; whereas if C be brought to one end of the link the engine will move ahead, and if brought to the other end the engine will move astern. By working the engine with the block C at a short distance from the end of the link, the engine, if constructed with a little overlap on the valve, will be worked more expansively; for as the extent to which a given amount of lap on the valve influences the cutting off of the steam varies with the throw of the valve, to reduce the throw with a given lap is tantamount to an increase of the lap with the same throw.

Gridiron and Equilibrium Valves.—The increasing size of steam engines, especially as applied to steam navigation, and the increased difficulty of moving valves of great size by hand to start the engines, together with the need of rapid motion, have pointed to the necessity of some modification of the older forms of slide valve by which these qualities would be realised. The D valve has consequently been so modified in its construction as to take the pressure of the steam off the back of it. This is accomplished by introducing a packing opposite to the upper part of the cylinder port, and another opposite to the lower part. The pressure on the back of the valve is thus made the same as the pressure on the front, and the resistance due to the friction of the packing is the only force that has to be overcome. The form of valve employed in locomotives, and hitherto much used in oscillating and other engines, is the three-ported valve, in which the upper and lower ports or passages leading to the cylinder, and a central port—communicating with the condenser in condensing engines, and with the atmosphere in high-pressure engines—are covered by a box with its open side against the cylinder, on which it is capable of moving steam-tight. But the length of the box is not sufficient to cover the whole three ports, but only one of the end ports and the central one. The box is set in a casing, and is surrounded by steam leading from the boiler; and the effect of moving up and down the box within the casing is to place each end of the cylinder alternately in connection with the boiler and with the atmosphere or condenser. This valve answers admirably for small engines, but the travel of the valve, which should be equal to the depth of the port, is too great to be convenient in the case of large engines moving at a high speed; and, further, the pressure of the steam against the bottom of the box is so great when acting over a large surface as to create an amount of resistance from friction that is not easily overcome. To remedy these defects, the gridiron and equilibrium forms of valve have been introduced. In the gridiron valve each port is divided into a number of narrow ports, by which the travel of the valve may be correspondingly abridged. In the equilibrium valve a ring is applied to the back of the valve, which rubs steam-tight against the

back of the valve casing. The interior of this ring communicates with the atmosphere or the condenser accordingly as the engine is a high-pressure or a condensing one, and by this expedient an equilibrium of pressure is established between the back and front of the valve, which discharges the friction and enables the valve to be moved with facility. In engines of large size, both of these expedients are generally introduced, as will be seen by a reference to fig. 8, which is a longitudinal section of part of one of the cylinders and of one of the valves of the screw engines of the steamer Great Eastern. Here A A are the cylinder ports, each of which is split into two narrow ports before reaching the valve face; B is the central port or passage leading to the condenser; C C C C are portions of the valve casing, which is filled with steam, and D is the valve which, as represented, is opening the upper ports to the steam, while the lower ports are open to the condenser; E is a ring fixed on the back of the valve, and moving with it, which rubs on the door which constitutes the back of the valve-casing. A small hole is bored through the back of the valve, so as to enable the space within the ring to communicate with the exhaust passage B, by which expedient the pressure of the steam is taken off the back, and the valve is rendered easily movable.

Fig. 8.



Gridiron Equilibrium Valve.

Starting Cylinders and Valves.—In some large marine engines, small cylinders have been introduced to move the link motion by which the movements of the valves of the main engines are controlled. In other cases, starting valves have been introduced. Both expedients were first applied by Mr. Bourne, the first in 1836, and the second in 1852.

Feathering Paddle-wheels.—In one variety of paddle-wheel, the float-boards which act upon the water are fixed in a radial position, like the buckets of an under-shot water-wheel, as has already been explained; and this species of wheel is largely employed both in the case of river and sea going vessels. Latterly, however, paddle-wheels with movable floats, of the kind represented in the preceding engravings, have obtained a marked preference, and vessels fitted with such wheels are found to realise a considerably increased speed. It will be remarked, that each float is hung upon an axis, whereby the inclination at which it enters or leaves the water may be altered; while by means of levers which are attached to the floats, and acted upon by rods converging to a centre eccentric to the shaft, a feathering motion is imparted to the floats by the revolution of the wheel. In river vessels the use of feathering wheels enables a small diameter of wheel to be employed without loss from angular impact; and with wheels of a small diameter, the engines may be worked with a greater speed, and will thus exert more power. In the case of sea-going vessels the diameter of the paddle-wheels cannot be materially reduced, whatever species of wheel is employed; for if the wheels were made very small, they would be immerged to the centre, or be out of the water altogether, if the sea should become boisterous: nevertheless, feathering wheels are advantageous in the case of ocean vessels also, as they act more beneficially than common radial wheels when deeply immersed, and with variable immersions, therefore, they maintain a greater average efficiency. There are objections, however, incident to the use of feathering wheels, which go far to balance these advantages. They are expensive both to make and to maintain. The wear and friction in such a multitude of joints is very considerable; and if any of the arms get adrift, or break, they will be whirled round like a flail, and may perhaps cut through the paddle box or even through the vessel. If the injury be of such a nature that the wheels cannot be turned round (and this has sometimes happened), it will follow that the engines will be virtually disabled until the obstruction can be cleared away; and if the weather be very stormy, or the vessel be in a critical situation, she may be lost in consequence of her temporary derangement. Nevertheless, feathering paddle-wheels have been on the increase in paddle vessels, and to diminish the risk of accident they are made very strong and sometimes of steel. The bearings and pins are usually made of iron covered with brass, and the eyes of the joints are lined with brass or, better still, with lignum vitæ or African oak.

Proportions of Marine Engines.—In oscillating engines the piston rod is usually made one-ninth of the diameter of the cylinder, and the crank pin is made about one-seventh of the diameter of the cylinder. The diameter of the paddle shaft must have reference not merely to the diameter of the cylinder, but also to the length of the stroke of the piston, or, what is the same thing, to the length of the crank. If the square of the diameter of the cylinder in inches be multiplied by the length of the crank in inches, and the cube root of the product be extracted, then that root multiplied by ·242 will give the diameter proper for the shaft in inches at the smallest part. The diameter of the trunnions is regulated by the diameter of the steam and eduction pipes, and these are each usually about one-fifth of the diameter of the cylinder; but it is better to make the steam trunnion a little less, and the eduction trunnion a little more, than this proportion. The steam and eduction pipes, where they enter their respective trunnions, are kept tight by a packing of hemp, which is compressed by a suitable ring or gland, tightened by screws. In land engines, the air pump and condenser are each made about one-eighth of the capacity

of the cylinder, but in marine engines they are made somewhat larger.

Proportions of Paddle-wheels.—The diameter for the paddle-wheel of a steam vessel depends mainly upon the variation of immersion which the ship is required to undergo. In river steamers, where there is little variation of immersion, the wheels should be small in diameter. If a line be taken in the length of each float, so that the mean pressure of the water against the float is the same above the line as below it, then this line will constitute a *centre of pressure*, and in determining the velocity of the wheel it is the velocity of the centre of pressure which should be regarded. In all cases the centre of pressure must move more rapidly through the water than the vessel, and the difference between the velocity of the wheel and the velocity of the vessel is termed the *slip* of the wheel. The slip which usually occurs in steam vessels is one-third or one-fourth of the velocity of the wheel; and an imaginary circle described upon the arms of the wheel at that point at which the velocity is the same as that of the ship, is termed the *rolling circle*. The rolling circle should fall above the level of the water. As a general rule, the larger the paddle floats, the more efficient will be the performance of the wheel, as is more fully explained in the article on the SCREW PROPELLER. In radial wheels, the usual practice is to introduce one float for every foot of the wheel's diameter, so that the floats are about three feet apart. In feathering wheels the floats are usually set twice this distance asunder.

Relations of Power and Speed.—With any given type of vessel, and any given power of engine, it is possible to predict, with very considerable accuracy, the speed which a steam vessel will attain. First, a coefficient must be found, which, when introduced into the computation, will give a result answering to that derived from experiment, and this coefficient will vary with the shape of the vessel. In the case of sea-going vessels of good average form, the coefficient is 800; and in the case of very sharp river vessels it is 1,000. Multiply this coefficient by the number of actual horse-power exerted by the engine [HORSE-POWER], and divide the product by the number of square feet in the transverse section of that part of the vessel lying beneath the water. Extract the cube root of the quotient, and this will be the speed which the vessel will attain in statute miles per hour. It is possible to make steam vessels too sharp to attain a minimum resistance, since the increase of length consequent upon increased sharpness involves a larger amount of rubbing surface in the bottom of the vessel, and the loss due to the increased friction may more than counterbalance the benefit accruing from the finer lines.

Circumstances conducive to the Efficiency of Marine Engines.—Supposing the boiler to be properly proportioned, it is necessary to see that the flues or tubes are kept clean, that blowing off be sufficiently practised if the boiler is worked with salt water, and that the furnaces are fed with coal in a regular manner—the coal being distributed evenly over the grate without allowing any holes to exist in the fire. The boilers should be covered with felt to prevent the radiation of the heat, and over the felt sheet lead should be spread, soldered at the corners, so as to prevent any drip of water from the deck having an injurious operation on the boiler. The steam pipes should be covered with felt, and then wrapped round with canvas. The cylinders should also be covered with felt, round which may be placed staves of wood, which should be hooped like a cask. The felt proper for this purpose is thick and soft, and is made expressly for the retention of heat. The steam should be used with a considerable pressure, and be worked expansively; but very little advantage will be derived from working expansively in steam vessels, unless the cylinders be clothed very effectually, so as to prevent the dispersion of the heat. Condensers, which condense the steam without mixing the resulting water with water from the sea, have now come into extended operation; for the only impediment to the use of steam of a considerably higher pressure in steam vessels, is the liability of the boiler to become incrusted with salt, when it might become red hot in some part, and perhaps burst; and this risk the use of fresh water in the boilers would prevent. A species of condenser, called *Hall's condenser*, which operated on the principle of a still, was at one time in pretty extensive use in steam vessels; but it was unskilfully applied in most cases, and the main benefit—the ability to use steam of a higher pressure—was not simultaneously sought to be attained. In Hall's condenser, the steam on escaping from the cylinder passed into a multitude of copper pipes, immerged in a cistern of cold water, and the steam being thus reconverted into water was returned by a pump to the boiler. In another species of condenser, suggested by Symington, a jet of cold water was to be employed, as is the present practice; but the fresh water with which the vessel started, instead of being discharged into the sea, was transmitted through a number of pipes which were kept cool by the sea water, and was returned to the condenser after having suffered sufficient refrigeration. The urgent demand for speed in steam vessels necessitates the employment of a large amount of power, which in its turn involves a large consumption of fuel. To reduce the consumption of fuel, without reducing the power, engines operating more expansively must be employed; but steam of a higher pressure is necessary for the satisfactory operation of such engines, and fresh water in the boilers is conducive to safety where a considerable pressure is employed.

Recent Improvements in the Steam Engine.—Up to the end of 1866 the chief improvements introduced into the steam engine, besides surface condensation in the case of marine

engines, are the use of superheated steam and the substitution of steel for iron in many of the parts. At a temperature answering to a pressure of forty pounds per square inch, salt water deposits sulphate of lime, not from concentration such as that which causes salt to be deposited by a saline solution, but from the mere application of a high degree of heat; and boilers working at a pressure of over forty pounds with sea water cannot be preserved from incrustation by any amount of blowing off. The insides of boilers using surface condensers, however, have been found to be much corroded by the galvanic action of the copper pipes in the condensers unless the pipes are tinned on the side exposed to the sea water; and all marine boilers, when new, should be worked with sea water at first, so as to deposit a thin enamel of scale within them. The steam is usually superheated by carrying it through or among pipes exposed to the heat of the smoke escaping to the chimney, and in practice it is found that if it is heated to a higher temperature than 315° Fahr. it will burn the hemp packings of the stuffing boxes, corrode the valve faces, and hinder the proper lubrication of the piston. Tallow subjected to a high temperature within the cylinder, will sometimes carbonise the piston, and convert it into a substance resembling plumbago. The crank shafts of screw engines are now very frequently formed of steel which is of about twice the strength of common wrought iron. Many screw engines, moreover, have the momentum of the moving parts balanced by counterweights upon the cranks, an improvement introduced by Mr. Bourne in 1853. The counterweights enable engines to work at a high degree of speed without jolting.

For further information on the steam engine, see the *Treatise on the Steam Engine*, by the Artizan Club; *A Catechism of the Steam Engine*, by J. Bourne, C.E.; or *Handbook of the Steam Engine*, by J. Bourne, C.E.

Steam Engine, Agricultural. There are two forms of agricultural steam engine. The first is a vertical or horizontal engine of simple construction, resembling the smaller classes of engines used to drive factories. The second—called a *portable engine*—more nearly resembles a locomotive, and consists of a tubular boiler set upon wheels, to enable it to be drawn from place to place, with a cylinder and its connections usually laid on the top of the boiler and giving motion to the fly-wheel shaft, which is carried across the top of the boiler by suitable brackets. These engines have now been very widely introduced for agricultural and miscellaneous purposes, some of the principal makers turning out nearly 1,000 engines per annum, or something under twenty per week. They are used for driving thrashing machines, for pumping water, for sawing timber, &c. and in some cases also the waste steam is used for steaming food for cattle. They average from eight to ten horses power each. For the most part, agricultural portable engines have a boiler resembling that of a locomotive, but smaller; there being a fire-box and a barrel containing small horizontal tubes for the transmission of the smoke to the chimney. But in a few cases the barrel of the boiler is placed in a vertical position with a cylindrical fire-grate and fire-box; and the fire-box, which is made of great height, has a number of tubes, closed at the lower ends, hanging from its top. These tubes being filled with water, and being acted upon by the flame, generate the steam. To enable a circulation of water to be maintained within these tubes, a thin tube of smaller diameter, and not reaching quite to the bottom, is introduced within each, and the water descends through the internal tube, and ascends through the surrounding annulus. In this case the cylinder is usually attached to the side of the boiler, and is inverted so as to work down to a shaft placed beneath. The wheels of portable engines are generally of iron, and the fore wheels are connected to the boiler by a ball-and-socket joint at the middle of the axle, so as to prevent the engine from at any time resting on three wheels. Usually the engine is drawn from place to place by horses; but in some cases the engine is made to move itself, by imparting motion to the wheels. Further information respecting agricultural engines of modern construction may be obtained in Bourne's *Catechism of the Steam Engine*, 11th edition.

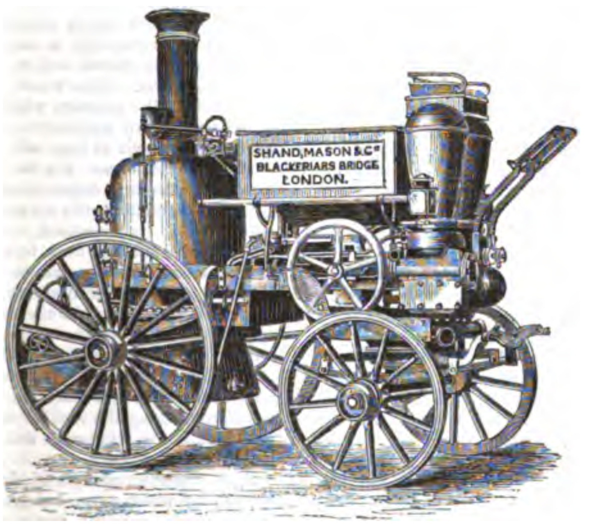
Steam Engine, Substitutes for the. It would be impossible here to recapitulate the expedients which have at different times been propounded for superseding the steam engine. The most promising are electricity or galvanism and hot air. The best forms of the galvanic battery are constructed with zinc surfaces, which are gradually consumed by oxidation. But a pound of coal consumed in a steam engine will produce twice the power generated in an electro-motive engine; and as the cost per pound of the coal is very much less than that of the zinc, it is most unlikely that galvanism will supersede steam, unless a carbon battery can be constructed in which coal will be consumed instead of zinc. The hot-air engine is a contrivance of greater promise; and Ericsson, in America, has constructed many hot-air engines, or, as he calls them, *caloric engines*, which are working successfully in different parts of the world. But as in these engines a cylinder and piston are employed, the temperature of the air cannot be made very high, and unless high temperatures are employed the air engine will not be more economical in fuel than the steam engine, although for some purposes it will be more convenient, inasmuch as the boiler is dispensed with. The most promising expedient of all at the present time is an air engine employing very high temperatures. Such an engine cannot directly employ a cylinder and piston, though it may act on some fluid, through the medium of which the power may be transmitted, or it may consist of a reaction engine, like a Barker's

mill, moving in water. In the case of steam vessels, propulsion may be effected by spouting out steam and smoke below the water at the stern. Various plans have been propounded for propelling in this manner, but none of them have yet been practically successful. That the steam engine will be superseded by a form of air engine using high temperatures, is highly probable; but an electro-motive engine would be preferable, provided that the power could be obtained from coal instead of from zinc.

Steam Fire Engine. An arrangement of pumps worked by steam for extinguishing fires, by projecting upon them a continuous stream of water from a suitable nozzle or spout-pipe.

The first steam fire engine we owe, in common with many other things, to the ingenuity of Ericsson, the eminent Swedish engineer, who subsequently to the completion of his locomotive, the Novelty, in 1830, constructed the first steam fire engine which was used with good effect in the fire which destroyed the Argyll Rooms about that time. In 1832, he constructed, for the king of Prussia, the steam fire engine called the Comet, which had two horizontal cylinders of 12 inches diameter, and 14 inches stroke, and two pumps 10½ inches diameter, and of the same stroke. This engine was set on wheels like those of an ordinary fire engine, and the flow of water was equalised by the aid of a great globular air vessel set behind the driver's seat. This engine weighed 4 tons. It raised its steam in from 13 to 20 minutes, and it threw 336 gallons of water per minute, or about 90 tons per hour.

Notwithstanding the success of Ericsson's early engines, steam fire engines did not come into extended use in this country for more than thirty years afterwards, and then various specimens of such engines came to us from America, which were inferior in constructive excellence to those which Ericsson had long before produced. Latterly, numerous steam fire engines have been constructed by Messrs. Merryweather and Son, Messrs. Shand, Mason, and Co., and by various other makers; and numerous competitive trials have been made to esta-



Steam Fire Engine.

blish the relative efficiency of the engines of the different makers. In the engines of both Messrs. Shand, Mason, and Co., and in those of Messrs. Merryweather and Son, the boilers are vertical; but in the former, the smoke is conducted through a number of vertical tubes to the chimney, whereas, in the latter, the form of boiler known as the *Field* boiler, is adopted, in which a number of tubes filled with water hang from the top of the fire-box, but terminate in close ends above the level of the fire-grate. In these tubes smaller internal tubes are introduced, to enable the water to circulate by descending the internal tube and ascending through the annulus left between the two. In some engines one cylinder is employed, and in others two, but Messrs. Shand, Mason, and Co.'s engines are formed with a crank, whereas Messrs. Merryweather and Son's engines are made without one, and are, therefore, not rotative engines. On the whole, the rotative form of engine appears to be best for pumping as well as for other purposes, as it can be driven faster, and enables the piston to be brought closer to the ends of the cylinder at the termination of the stroke, thereby saving steam. The form of pump commonly used is the bucket and plunger pump, first introduced by Mr. David Thomson, in the Richmond water-works in 1845, and which resembles a common suction pump, with a very thick rod, which acts as a plunger, and the pump consequently forces

both in the ascent and descent of the bucket, but draws only during the ascent of the bucket. In some cases the cylinders and pumps are vertical, and in others horizontal. The figure on p. 591 represents one of Messrs. Shand, Mason, and Co.'s horizontal engines. In an experiment made in 1864 with an engine of this kind with a single cylinder and small fly-wheel, the cylinder being 7 inches diameter and 8 inches stroke, and the pressure of steam 145 lbs. per square inch in the boiler, and 128·16 lbs. in the cylinder, a jet of water 1⅛ inch diameter was projected under a water pressure of 125 lbs. per square inch, the engine making 165 revolutions per minute, with 5½ lbs. per square inch of back pressure resisting the piston. In this case the engine exerted 32¼ indicated horse-power; and as the total weight of the engine was only 32 cwt., the weight was only one cwt. per indicated horse-power. In these engines a small piston, which is pressed against a spring by the water which is being forced out of the jet pipe, governs the speed of the engine by moving suitably the throttle valve in the steam pipe. In April 1866, Messrs. Shand, Mason, and Co. delivered to the Metropolitan Fire Brigade seven of their vertical steam fire engines, those previously in use in that force having been found to act in a most satisfactory manner. They also about the same time sent out three engines to Bombay, one of which was tested in London before being shipped. Steam of 60 lbs. pressure was raised from cold water in 8½ minutes, which threw a jet of water an inch in diameter 150 feet high, and 228 feet horizontal. In the fire brigade stations, it is usual to keep the water in the boilers of the fire engines warm by keeping a small jet of gas alight in the furnace, and by this simple expedient the steam is almost sure to be up before the engine can reach even the nearest fire.

Steam Gauge. An instrument intended to measure the pressure of the steam in the boiler. Steam gauges are of different kinds. One that has been much employed is the *mercurial steam gauge*, which consists of a small U tube of iron which is filled with mercury about half-way up, and the top of one leg communicates with the boiler, while a small wooden float projects above the top of the other leg and points to the graduations on a scale divided into inches, the float pointing to 0 when the steam is not up. If, now, steam be raised in the boiler, the mercury will be depressed in one leg and raised in the other, and every rise of an inch on the scale indicates a pressure equal to that due to two inches of mercury, or very nearly a pound pressure per square inch. Another form of steam gauge is a conical glass tube containing air, against which mercury or some other liquid is forced by the steam; another form, now much used, is that known as *Bourdon's gauge*, which consists substantially of a coiled flat elastic tube, into which steam enters, and the steam causes the tube to assume more nearly the cylindrical form, and simultaneously to uncoil. The amount of uncoiling, as shown by a suitable hand, indicates the amount of pressure.

Steam Gun. A contrivance by which projectiles used in warlike operations may be discharged by the expansive force of steam. This invention is due to Mr. Jacob Perkins.

If a strong close iron vessel, having two valves, one opening inwards and the other outwards—the latter being loaded with some definite pressure—be *completely* filled with water, such a vessel may be heated to the temperature corresponding to the pressure with which the valve is loaded without causing any portion of the water in it to be converted into steam. To render the effect more easily understood, let us suppose that the valve is loaded with a pressure of fifty atmospheres. The temperature of water evaporated under that pressure being 510° [STEAM], the vessel may be raised to any temperature not exceeding 500°, without having any of the water contained in it converted into steam. If the temperature to which the water is raised be 500°, and a cubic inch of water at common temperatures be forced into the vessel through the valve which opens inwards, water being sensibly incompressible, a cubic inch of water at 500° will be forced out at the valve which opens outwards. This water, being no longer subjected to the pressure which kept it in the liquid state, will suddenly expand and flash into steam, which at first will have a pressure of fifty atmospheres, but as it expands will have its pressure diminished in nearly the same proportion as the volume into which it swells shall be increased. Since, however, 500° is not sufficient heat to enable the whole of the water thus ejected to pass into steam [STEAM], that part of it which will assume the vaporous form will take the requisite amount of latent heat from the sensible heat of that portion which remains in the liquid state. As this latter portion will still retain a considerable temperature, it may be conducted to a vessel containing the feed for the heated vessel just mentioned, whence it will be again forced into that vessel.

Such was the principle of Mr. Perkins' *generators*; by which term he denominated those close vessels in which water was raised to a high temperature without being converted into steam.

Now, if the valve through which the heated water is ejected be supposed to be in communication with the barrel of a gun or piece of ordnance, in the same manner as the barrel of an air gun is in communication with the hollow metallic ball in which the air is compressed, a projectile may be discharged by the expansive force of the water ejected from the valve, precisely as the ball of an air gun is projected by the expansive force of the compressed air.

As the water may be ejected from the valve either in a constant stream or by a rapid succession of jets, the projectiles may be discharged from the barrel as rapidly as it is possible for them to be brought under the action of the

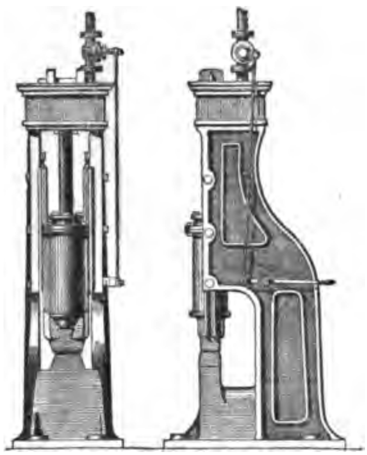
steam; and since the heating of the barrel tends only to increase the elastic force of the steam, there appears to be no other practical limit to the action of such an engine of offence except that which may be imposed on the heating power applied to the generator.

Of the abstract practicability of applying steam in this manner as an offensive engine, there can be no doubt. Both theory and experiment conspire to establish it; but of the comparative efficacy, convenience, and economy of it, compared with gunpowder, many doubts will present themselves to all who duly reflect on the circumstances by which the innovations are surrounded. The necessity of using a steam generator of any kind obviously limits the application of such an instrument to particular cases, and even in those special cases the necessity of employing a generator or boiler which shall reconcile a ready conduction of the heat to the water, with great strength and solidity in the heating vessel, must continue to be regarded as a weighty difficulty. Without a very high pressure of steam the projectile cannot acquire an adequate velocity with any ordinary length of bore; and the use of steam of a very high pressure is dangerous and inconvenient. By greatly increasing the length of the gun, the same effect may be obtained with a smaller pressure; but this expedient is also inadmissible. Hence the steam gun could never come into effect for any but very small calibres; and the places where small guns come into use are precisely those in which it would be most difficult to employ a steam boiler, viz. in the field, in boat service, &c.

Steam Hammer. A heavy hammer, moved by a steam engine, employed chiefly for forging masses of iron and steel, but also for crushing quartz in gold mining, and for other purposes in the arts. Hammers lifted by cams upon a revolving shaft, deriving its motion either from a water wheel or a steam engine, have long been used in certain processes of the iron manufacture. But in the steam hammer there is no intermediate mechanism intervening between the engine and the hammer, and the force and number of the blows are regulated by suitably governing, by a proper valve, the flow of steam to the engine.

The first proposal to apply a steam engine to work a hammer direct was made by Mr. Watt in 1784, but it was not until upwards of half a century later that the problem was practically gone into and solved by Mr. James Nasmyth, then of Patricroft near Manchester. The first steam hammer actually set to work was erected by M. Bourdon in France. But M. Bourdon confessedly obtained his ideas on the subject at Mr. Nasmyth's works, which had been visited by M. Bourdon when he was in England, and to whom the plans of the steam hammer were shown along with the plans of other tools and machines then in progress. But the completion of the steam hammer having been delayed by the progress of other work, and M. Bourdon having begun the construction of such a hammer immediately on his return, it so happened that the French hammer was at work before the English one. In Watt's proposed steam hammer the cylinder was at one end of a wooden beam, while the hammer was at the other, and the hammer, instead of moving vertically as modern steam hammers do, moved in the arc of a circle, being fitted with a wooden shank like the old forge and tilt hammers when moved by cams upon a revolving shaft. But in Nasmyth's arrangement the cylinder is erected over the anvil, and the piston rod which passes through the bottom of the cylinder has the hammer fixed to its lower extremity, the hammer being directed vertically by suitable guides. In Condie's arrangement, the piston is stationary and the cylinder moves, the hammer being attached to the bottom of the cylinder; and the piston rod, which is a stationary cylindrical pipe, serves to convey the steam to and from the

Fig. 1. Fig. 2.



Light Steam Hammer.

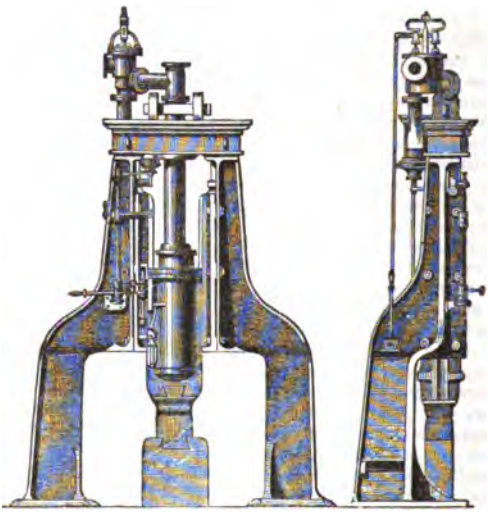
cylinder. Figs. 1 and 2 are a front and side view of Condie's 3½ cwt. hammer, and figs. 3 and 4 a front and side view of Condie's 6 cwt. hammer.

It will be observed that in the lighter hammers the standard is single and the hammer is overhung, while in the heavier hammers the standard is double and the moving cylinder is guided between the two parts. In the early hammers the weight was raised by the pressure of the steam, and the hammer descended by gravity alone; but in all modern hammers the steam presses the hammer down as well as raises it up. Many of the modern hammers are of great size, and of these the standards are generally formed of wrought iron. It is found that hammers of great weight are quite indispensable for consolidating and giving soundness to the Bessemer steel, and it is for this purpose that the very heavy hammers are chiefly employed. In Neilson's radial hammer the cylinder

and hammer are carried on the end of a radial arm, which may be swivelled round a stationary pillar, and the anvil block, which is fitted with various kinds of anvils and dies, is formed like a quadrant struck from the centre of the pillar, to the end that the hammer may by swivelling it be brought down on any particular die. Hammers working horizontally, so as to strike the mass of incandescent metal upon the anvil simultaneously on opposite sides, have also been introduced, and in some cases, too, such a duplex horizontal hammer has been used in conjunction with a hammer working vertically, so that the metal is compressed on four sides at once, the dross and clinker being forced out at the ends.

Steam Hammer for Pile-driving.—An ingenious machine invented by Mr. Nasmyth, now in general use in government and other large works. 'It consists of a steam cylinder, closed at the bottom, but with openings in the top to allow the passage of air; a piston works in it, having its rod passing through a steam-tight aperture in the bottom. To the piston the monkey or driver, which weighs 2½ tons, is attached, and is thus suspended. The machine is worked by high-pressure steam, which being admitted at the bottom of the cylinder by the induction pipe, raises the piston, and, with it, the monkey attached to it. The instant it arrives at the height required, it closes the induction pipe, and, opening the eduction pipe (also at the bottom of the cylinder), the steam escapes, and

Fig. 3. Fig. 4.



Heavy Steam Hammer.

the piston, with the monkey attached to its rod, falls freely on the head of the pile. A large heavy cap of iron, with a hole to allow the head of the pile to pass through, slides between the upright standards, and guides the direction of the pile. The monkey and cylinder also follow the course of the pile, guided by the same uprights, between which they slide.' The entire weight of the steam hammer part of the apparatus, resting all the while on the shoulders of the pile and following down with it, materially assists its penetration into the soil.

The saving of labour effected by this contrivance is very great. A stage, which carries the machine, boiler, workmen, and everything necessary, moves along a railway. Having driven one pile, the machine moves onward the regulated distance; it then picks the next pile out of the water, hoists it high in the air, drops it into its exact place, then covers it with the great cap; the monkey immediately acts, giving blows at the rate of seventy-five in a minute. The whole operation of raising a pile from the raft, putting it in its place, and driving it to the required depth, occupies generally from two to four minutes. By the old method of pile driving, a comparatively light weight (about 12 cwt.) is made to fall from a great height, and the blows succeed at intervals of about five minutes. By the new machine, a very heavy weight (about 50 cwt.) falls through a height of only three feet, and the blows fall 375 times more frequently.

In a paper communicated to the British Association for 1841, Dr. Greene gave the following instance of the state of the heads of two piles, as driven by the two methods:—

'One was fifty-six feet long, driven by a monkey of 12 cwt. falling from a great height, and making only one blow in five minutes, and requiring twenty hours to drive it; this, though protected by a hoop of iron, was so split and shattered on the head, that it would require to be reheaded to drive it any farther. The other, though sixty feet long, was not even supported by an iron hoop, and the head is as

smooth as if it were dressed off with a plane. It was driven with a hammer of 50 cwt. and only three feet fall, making seventy-five blows in a minute, and was put into its place and finished in four and a half minutes.'

Steam Jet. A jet of steam suffered to escape from a pipe, and employed either to accelerate the flow of smoke up a chimney by being projected upwards in the manner in which the waste steam is projected through the blast pipe into the chimney of a locomotive; or it may be employed to cause a current of air for purposes of ventilation, as was done in the Houses of Parliament, where the ventilation was promoted by steam jets. The arrangement is suitable for ventilating steam vessels, by sucking the vitiated air from the cabins. A species of steam jet, called *Delabarre's steam jet*, is sometimes used, of which the peculiarity is, that the jet opens into a short piece of larger pipe, open at both ends, and that into another piece still larger in diameter, and so on; and the air or smoke is sucked in between the successive pieces. Liquids as well as gases may be moved by a jet of steam; and one form of the steam jet, used for forcing water into boilers to feed them, is known as *Giffard's injector*. The action of this instrument appears at first sight paradoxical, as a jet of steam from any given boiler will not only force water into that boiler, but also into a boiler of a still higher pressure. It is essential to the action of the instrument that the feed water shall not be too hot to condense the steam; and the water in the steam must be viewed as water moving with the high velocity with which the steam moves, and which consequently contains sufficient vis viva to force the water in against the pressure within the boiler. Latterly the steam jet has been tried for propelling vessels.

Steam Navigation. The art of propelling vessels by the instrumentality of the steam engine. Vessels so propelled are called *steam vessels*; and the navigation of seas or rivers by steam vessels is termed *steam navigation*. The propelling instrument, by means of which the steam engine acts upon the water, may be the paddle-wheel [Steam Engine] or the screw [Screw Propeller], or any other medium for communicating power; and the vessel is forced forward by the backward pressure of the paddle boards or screw upon the water, just as a boat is forced forward by the reaction of the oars, or as the body of an aquatic bird is propelled by the action of the feet. The pressure with which the vessel is forced forwards is in all cases the same as that with which the water is forced backwards; and this pressure will remain unchanged whether the surface pressing the water be large or small, being dependent altogether upon the power of the engine, other things being equal. But if the propelling surface be large, the water will be moved backwards through only a small distance, while the vessel is moved forward through a great distance, whereas if the propelling surface be small, then with only the same forward motion of the vessel there will be a larger backward motion of the water, and more steam will be expended in producing the same result.

History of Steam Navigation.—Vessels propelled by paddle-wheels driven by oxen were employed by the Carthaginians, and were introduced by them into Sicily, from which country the Romans obtained a knowledge of that method of navigation. In 1543, Blasco Garay, a sea captain in Spain, is reported to have exhibited to Charles V. a vessel propelled by wheels of this kind which were driven by steam; but recent investigations show this story to have been apocryphal. In 1618, and again in 1630, patents were granted in England to David Ramseye for propelling vessels by fire or steam. Various projects for propelling vessels were proposed after this time by Grent, Lin, Ford, Toogood, Chamberlaine, Bushnell, Papin, Duvivian, Savery, Duquet, Dickens, Allan, and Hulls; but so long as the steam engine remained in the cumbrous and ineffective state in which it then existed, no power profitably commensurate with the additional weight could be imparted to a vessel. In 1737, Hulls published a pamphlet describing his mode of propulsion, of which the main features were a paddle-wheel placed at the stern and driven by an atmospheric vacuum engine within the vessel. In 1787, Mr. Patrick Miller, of Dalswinton in Scotland, published a pamphlet describing a new species of vessel which was to be driven by paddle-wheels; but these wheels were to be worked by manual labour by means of capstans. With a vessel constructed by Mr. Miller upon this plan, it was found that a considerable speed was attainable; but the operation of turning the capstan was found to be very laborious, and it occurred to Mr. Taylor, a tutor in Mr. Miller's family, that a steam engine might be applied to perform this work. Mr. Taylor, having shown that such an engine might be introduced without setting the vessel on fire, was commissioned by Mr. Miller to order an engine of an acquaintance of Taylor's, called William Symington, a young engineer of much ingenuity. This engine was made and introduced into a pleasure boat, which was many times tried successfully on the lake of Dalswinton. Mr. Miller then built a vessel on a larger scale, the engine of which was made at Carron. This vessel was tried on the Forth and Clyde canal in 1789, and realised a speed of nearly seven miles an hour. Nothing further was done in the matter, however, till 1801, when Symington received an order from Lord Dundas to construct a steam vessel for the Forth and Clyde Canal Company. Watt's patent having by this time expired, the engine was made upon his plan, and, with Watt's double-action cylinder, the performance of the vessel was satisfactory in every respect. From an impression, however, that the waves which were created would injure the banks of the

canal, this new method of propulsion was not further pursued.

In 1801, shortly after this vessel was completed, she was visited by Robert Fulton, a native of America, at whose desire Symington caused the vessel to be put in operation in order that he might witness her performance. Symington's belief was that the speed of the vessel was impaired by the narrowness of the canal, and Fulton remarked that such an objection could not have existence in the great rivers of North America, where vessels of such a character would confer important advantages. Shortly after this time, Fulton commissioned Boulton and Watt to construct for him an engine which was to be put on board a vessel in America. This vessel was to be propelled by paddle-wheels in the manner previously practised in Scotland. The name of the vessel was the Clermont; she was launched and tried in 1807, and performed her assigned duties in a satisfactory manner. Numerous vessels resembling the Clermont were soon after this time built in America. In 1812, Mr. Henry Bell, of Helensburgh on the Clyde, constructed the Comet, the first steam vessel employed for commercial purposes in Europe. Numerous other vessels resembling the Comet were soon after this built in the Clyde, and steam navigation before long came into general use in all parts of the kingdom. Mr. David Napier, of Glasgow, who had constructed the boiler of the Comet, and who soon signalised himself in this department of engineering, was the first person who sent steam vessels to sea. He established lines of communication between Greenock and Belfast, and, subsequently, between Dublin and Holyhead, and between Dover and Calais. The method of combining two engines with their cranks set at right angles with one another, so as to obviate all danger of the engine stopping at the dead point, and to make the power uniform through the revolution, was a suggestion of Mr. Watt's. When the City of Edinburgh, constructed by Boulton and Watt, was set to run between London and Leith, it was found that the sea water in a voyage of this length acquired, from the continual evaporation of the water without removing the salts, such a degree of concentration that it was no longer fit for the production of steam. The vessel had, therefore, to be stopped in the middle of the voyage, the water let out of the boiler into the hold, and a fresh supply of water to be introduced from the sea. To remedy this inconvenience, Boulton and Watt applied *change pumps* to the vessel, which by continually removing a portion of the super-salted water during the voyage, prevented an injurious concentration from being attained. They afterwards superseded the change pumps by *blow-off cocks*, which on being turned at intervals allowed a portion of the super-salted water to escape overboard. This expedient for preventing an accumulation of salt in the boiler is still generally employed in vessels not employing external condensation, which, however, has now become very general, to enable the boiler to be fed with fresh water, and thus to render the use of steam of a higher pressure practicable with safety, and to obviate the risk of bursting from the accidental accumulation of salt upon the furnaces, when they might become red hot and collapse from the pressure of the steam.

The side lever form of engine, still to some extent employed in steam vessels, was settled by Boulton and Watt at an early period in the history of steam navigation; but the oscillating engine invented by their foreman, Mr. Murdoch, towards the close of the last century, is now generally preferred in the case of vessels propelled by paddle-wheels. It is, however, mainly from the admirable manner in which the details of this species of engine have been carried out by Messrs. Penn and Son, that it has obtained such favourable acceptance and such wide notoriety. Tubular boilers for marine purposes were patented by Mr. Bourne in 1838, but were first practically introduced by Messrs. Penn and Son, and Messrs. Miller and Ravenhill, about 1844.

Ocean Steam Navigation.—Lines of steam navigation now connect together nearly all the countries of the world. Most of the companies carrying on these lines of communication receive large yearly payments from the government for the conveyance of the mails, without which the existing measure of efficiency in the vessels could not be maintained; and it may be taken as an axiom in steam navigation, that no line of distant communication in which a high rate of speed is necessary can be profitable unless supported by a government subvention, or unless some other equitable payment is made for carrying the mails. Some of the vessels carrying on ocean navigation are of 800, 1,000, and even 1,200 nominal horse-power. The actual power of such vessels should be at least six times the nominal. In sea-going steam vessels from 20 to 21 miles an hour is the utmost speed that has yet been attained; but in some cases, the actual power is as great as nine times the nominal. For screw vessels, direct acting engines, or engines without gearing, are now nearly universal. The type most generally and most justly preferred is the double piston rod or steeple engine, laid on its side. [SCREW PROPELLER; TURRET SHIP.]

River Steam Navigation.—The extent of steam navigation upon the rivers of this country is not considerable, the rivers being only in a few cases, or through an inconsiderable part of their length, of sufficient volume to enable navigation to be carried on upon them. Upon the Thames and also upon the Clyde there are many river steamers, well adapted to the functions which they have to perform; but in no case are these vessels of large dimensions or great power. In America, however, where the rivers are of a far larger volume than in this country, and perform a far more important part in the

means of internal communication, there are river steamers of nearly 400 feet in length, and with paddle-wheels 50 feet in diameter, and some of these vessels are said to have attained a speed of 24 miles an hour. The engines are usually set upon the deck, and are formed in the same manner as a common land engine—the beam being poised high in the air and the connecting rod extending from the beam down to the crank. The river steamers of America more nearly resemble arks than ships, as they are built with several decks or stories resting on the hull, which is always made very sharp, so as to enable a high rate of speed to be attained. A pressure of 50 lbs. per square inch is commonly maintained in these engines, if condensing. The stroke of the piston is always very long relatively with its diameter; the steam is of considerable pressure, and is used expansively. The engines are of rude construction compared with English engines, but they are cheap and answer their intended purpose. Upon the Mississippi and its tributaries most of the engines are high-pressure, with the cylinders lying horizontal as in locomotive engines, and accidents by explosion and fire are of frequent occurrence. Some of these engines are worked with steam of 250 lbs. pressure upon the square inch. The muddiness of the water of the Mississippi causes it to froth very much and the boilers to prime, unless steam of a high pressure be employed, which, as it occupies a less volume, occasions less agitation in the water as it rises to the surface. The cabins of American steamers are in nearly all cases very handsome and spacious; the boilers are usually disposed at the sides of the vessel behind the paddle-boxes, so that the ashes fall into the river; and the steering wheel is placed on the upper deck near the bow, and communicates with the rudder at the stern by means of iron rods or chains.

Steam Navigation upon shallow Rivers.—The shallowness of many of the rivers of the continent, on which it became important to establish steam navigation, has led to the introduction of very light vessels upon them. Upon the upper part of the Rhine, and upon the Moselle, there are vessels plying which draw only 11 inches of water. Upon the Loire there are vessels plying which draw only from 8 to 10 inches of water, and upon the Red River, a tributary of the Mississippi in America, there are vessels plying which are said to draw only 7 inches of water. These vessels of course do not carry cargo, but only passengers. Mr. Bourne introduced a species of steam train for navigating the rivers of India, and especially the Indus, consisting of a steamer of light draught towing a train of shallow barges laden with cargo; and it is reckoned that by this simple expedient ten thousand miles of river, now inaccessible, would be laid open to commercial intercourse by steam.

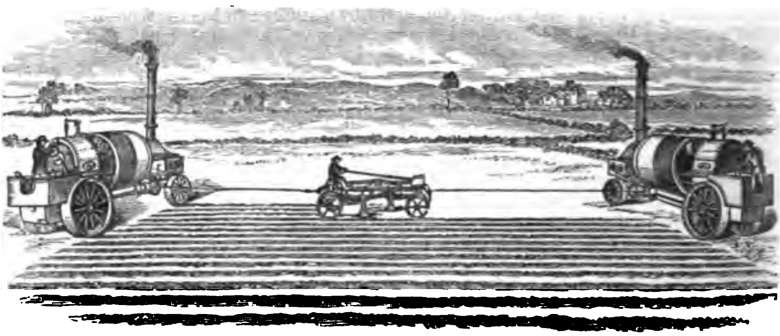
Steam Navigation upon rapid Rivers.—A method of towing barges by steam has for some years past been in successful operation upon the Rhone, which appears likely to be of service in all cases where rapid rivers have to be ascended with heavy loads. Upon the paddle shaft a toothed drum is fixed which engages an endless chain. This chain passes round a great wheel like the fly-wheel of an engine, but armed with projecting spikes, which is placed at the lower extremity of a wooden frame hinged at its upper end, so that it can rise and fall with the irregularities of the river bed, and this wheel, being put into revolution with about one-third of the speed of the paddles, hauls the vessel up against the stream by means of the chain. The paddles are thrown out of action when this wheel is in operation, but are used in descending the river, when the great wheel, which rises through a well in the centre of the vessel, is hoisted out of the water.

Steam Ploughing. The art of cultivating land by the steam engine has now been practically matured; but as the requisite machinery would be too expensive for most farmers to purchase, and too powerful for them to require constantly, companies have been formed in different localities to let out steam machinery for ploughing and thrashing on hire. Various expedients for ploughing by steam have been tried, one of which was a species of digging machine in which a wheel armed with spades or diggers was rotated by an engine, and which simultaneously turned up the ground and drew forward the machine. By another method, a traction engine, made either with an endless railway like Boydell's, or very broad wheels and projecting grippers like Bray's, advanced over the ground, drawing a number of ploughshares behind it. But the method of ploughing now generally adopted consists in drawing a frame on wheels, and armed with a sufficient number of ploughs, backward and forward over the field by means of a rope of steel wire wound up by a portable agricultural steam engine. There are two systems of rope tillage, in one of which a single engine is used, and in the other two engines. In the first system, the engine is placed at one end of the field, a pulley, armed with a suitable anchor for fixing it to the ground, being placed at the other end. A wire rope, proceeding from the engine along the length of the field, passes through the pulley and returns again to the engine. This rope is then drawn backward and forward across the field, carrying the frame of ploughs with it, which frame is so poised on central wheels that when the set of cutters in front of the wheels is in the earth the other is out, and vice versâ, to the end that the ploughs may act equally in whatever direction the rope is pulled. In the other system—which appears to be preferable—two engines are used, one being placed at each end of the field with a rope extending between them, and the same species of plough is attached to the rope and is drawn alternately backward and forward by the engines alternately winding and unwinding—the engines being of course advanced through a

suitable distance along the ends of the field at each cut that is taken. This arrangement is shown in the annexed figure, which represents Savory's apparatus for steam ploughing. But there are various other forms of apparatus, such as Fowler's, Howard's, Smith's, &c. Steam ploughing companies generally charge farmers 12*s*. per acre for ploughing their land 12 inches deep, 10*s*. for 9 inches, and 8*s*. for 7 inches. The farmers, by the aid of such companies, get their stubbles and seeds broken up and crushed at two operations for 18*s*. per acre, and their ploughing and digging performed at from 10*s*. to 18*s*. For ploughing with short breasts for turnips or barley before sowing they are charged 12*s*. 6*d*. per acre. Fowler's tackle gets through $1\frac{1}{4}$ acre per hour, and works without trouble or breakage. Howard's machinery is also well spoken of, and works through stony and uneven ground without injury. The engines come to the ground with the steam up, and when two engines are employed there is no time lost in fixing tackle, which on the single-engine system occasions much delay.

Steam Press. [PRINTING MACHINE.]

Steam Riveting Machine. A machine for riveting, by the pressure or percussion generated by a steam engine, the plates of metal which enter into the composition of boilers and other similar structures. Formerly, the plates of metal having been punched by a punching press, red-hot rivets were inserted, which were clinched over by hand hammers, and this mode of procedure is yet practised in situations where the riveting machine cannot be applied. But work riveted by machine is not only cheaper than that riveted by hand, but is sounder and better, while the machine forces the plates so closely together that very little caulking suffices to make the joints tight.



Steam Ploughing.

There are two kinds of riveting machines. In the one the die for forming the rivet is pressed against the plate in the same manner as the punch is pressed in a common punching machine; in the other, it is pressed forward by a piston urged by steam in the same way as a steam hammer. The first of these varieties is the form of riveting machine first contrived by Mr. Bourne in 1834, and subsequently adopted by Mr. Fairbairn. The second variety, which is the offspring of the steam hammer, was not contrived until the Menai tube came to be constructed. The steam hammer form of riveting machine is the most convenient, as it does not require any adjustment for the thickness of the plate, and it is the form now generally preferred.

Steam Room. The space in a boiler appropriated to the storage of the steam, and which includes the whole content of the boiler except that occupied by the water and flues.

Steam-made Ice. One of the most remarkable applications of the steam engine is to the manufacture of ice, which is accomplished by forcing the heat out of air by mechanical compression, and then by allowing the compressed air to expand, whereby such a demand is made for the restoration of the heat before forced out as to produce a great reduction in the temperature of surrounding objects. Mr. Bourne states that in his first visit to India, in 1847, the inconveniences caused by the heat led him to contrive a machine in which cold would be produced by the expansion of air previously compressed by a steam engine, the expanding air being at the same time used to work the punkahs or great fans which are suspended from the ceilings of the rooms to produce an agitation of the air. In the first ice-making machine constructed on this principle in America, the vapour of ether was employed instead of air, a pump being introduced to create a vacuum, when the ether evaporated rapidly, producing great cold, and this vapour being then pumped into a vessel under pressure it assumed the liquid form, when it was again available to be evaporated as before. Brine was made to circulate through pipes traversing the refrigerated ether, and these pipes being continued through cisterns of water, the water was so much cooled by the contact of the cold pipes that it froze and was taken out in blocks. This machine was introduced into India and some other tropical countries. But it was found that the ice made by it was opaque instead of being transparent like ordinary

ice, a peculiarity imputed to the circumstance of the freezing having been begun from beneath the water instead of from the surface. It was also found that the use of ether was objectionable and dangerous, and in the Bathgate paraffine oil works, where one of these machines was employed to separate the paraffine by refrigeration, it was judged expedient to discard the ether and to revert to the use of air as the refrigerating agent, which accordingly was done under the direction of Mr. Kirk, the engineer of the works. The first experiments were not successful owing to conduction, the presence of moisture in the air, and the absence of a regenerator; but by using dry air and introducing a regenerator of wire gauze, like that of Stirling's air engine, a very efficient refrigerating apparatus was obtained. A still larger machine was erected by Mr. Kirk at the same works in 1864, and an account of it will be found in *Engineering* for January 26, 1866. This machine has two cooling cylinders of 36 inches diameter and 2¾ inches stroke, and one compressing cylinder of 15 inches diameter and 30 inches stroke. Pressure of air in one cylinder, 100 lbs. per square inch maximum and 52 minimum; revolutions per minute, 66; indicated horse-power spent in driving, 23; quantity of cooling water per minute, 4·3 gallons; temperature of inflow, 62°—of outflow, 94°; quantity of brine cooled per minute, 6·7 gallons; temperature of inflow, 32°—of outflow, 23°. Professor Rankine calculates that there are 767 units of heat generated per minute in this machine, which are equivalent to 592,124 foot pounds per minute or 18 horse-power. But the power really consumed, as shown by the indicator, is 23 horses, leaving 5 horses not accounted for, and lost by leakage of heat or otherwise. In many of the arts the power of cooling to any desired temperature is most important, and in tropical climates refrigeration by steam, or other cheap available power, may be easily effected and will be productive of the most momentous benefits, especially in hospitals, barracks, offices, churches, and in all large places of assembly.

Steamer. A term vaguely used for any vessel in which the propulsion is by steam, otherwise than as an auxiliary motive power.

Stearates (Gr. στέαρ, *fat*). Stearic acid forms both neutral and acid salts. The stearates of the alkalies are soluble in water, alcohol, and ether; but when the aqueous solutions of the neutral compounds are largely diluted, they deposit flakes of the acid stearate. The stearates of the alkaline earths may be obtained by double decomposition, from bistearate of potash: they are insoluble. Stearate of potash is the basis of *soft soap*, and stearate of soda of the principal *hard soaps*: these stearates are separated from their solutions in water by excess of alkali, and also by chloride of sodium and some other salts. Stearate of lead is the basis of lead-plaster.

Stearic Acid ($HO, C_{36} H_{35} O_3$). When stearin is saponified, it is resolved into stearic acid and glycerine, a change which has been represented by the following equation:—

$$\underbrace{C_{114}H_{110}O_{12}}_{\text{Stearin.}} + 6HO = \underbrace{C_6H_8O_6}_{\text{Glycerine.}} + \underbrace{3[HO, C_{36}H_{35}O_3]}_{\text{Stearic acid.}}$$

The acid may be obtained by decomposing a soluble stearin soap by tartaric acid, and purifying the product by solution in boiling alcohol, from which it separates in crystalline flakes; it may be further purified by solution in ether. It is white, inodorous, and tasteless, but it reddens litmus: it fuses at about 160°, and may be distilled in vacuo, but when highly heated in the air it undergoes more or less change. Stearic acid may be distinguished from stearin by its ready solubility in a boiling solution of potash.

Stearin (Gr. στέαρ). That part of oils and fats which is solid at common temperatures. It is a compound of stearic acid and glycerine, and is resolved into those proximate components in the process of saponification. It fuses at about 140°. The formula assigned to stearin is $C_{114}H_{110}O_{12}$. Its resolution into glycerine and stearic acid in the process of saponification has been represented by the following equation:—

$$\underbrace{C_{114}H_{110}O_{12}}_{\text{Stearin.}} + \underbrace{6HO}_{\text{Water.}} = \underbrace{C_6H_8O_6}_{\text{Glycerine.}} + \underbrace{3[HO, C_{36}H_{35}O_3]}_{\text{Stearic acid.}}$$

Steatite (Gr. στέαρ, στέατος, *fat*). A massive variety of Talc, with a smooth greasy feel, like that of suet, and so soft as to yield to the nail. It is a hydrated silicate of magnesia, and is found near the Lizard Point in Cornwall, at Glyder Rock and Moel Siabod in Carnarvonshire, Portsoy in Banffshire, Canada, &c.

Steatite is a material much used in China for carving into grotesque figures [Agalmatolite]; and slabs of the same stone are, from their refractory nature, employed for lining ovens and furnaces. It is also made into gas-burners, which possess the advantage of not corroding or becoming stopped up. [Soapstone.]

Steatoma (Gr. στέαρ). A tumour, the contents of which are of the appearance and consistency of hard fat.

Steel (Ger. stahl, Dutch staal). This most useful and curious substance is a compound of iron and carbon. The relative proportions vary in steel of different qualities; but in that used for ordinary purposes the carbon rarely exceeds 2 per cent., and is generally about 1·5 per cent. Certain kinds of iron are preferred to others in this manufacture; but this relates entirely to its purity, which is the essential requisite. Steel is sometimes made by a process called *cementation*, which consists in filling a proper furnace with alternate strata of bars of the purest malleable iron and powdered charcoal, atmospheric air being carefully excluded from the boxes containing the bars, and the whole kept for several days at a red heat. By this process carbon penetrates, and combines in the above small relative proportion with the iron, the texture of which, originally fibrous, becomes *granular*, and its surface acquires a *blistered* character. Much of the steel now used is,

however, made directly from cast iron, by removing a portion of the carbon which the latter contains. This is effected by exposing the molten iron to a current of air, either on the sole of a REVERBERATORY FURNACE or in large egg-shaped iron vessels lined with fire-clay. The latter process is known as Bessemer's, and yields an excellent product. Steel made in the reverberatory furnace is commonly termed *puddled steel*. The malleability of steel falls far short of that of iron; but it is harder, more sonorous and elastic, and susceptible of a higher polish, while it has less tendency to rust. At a red heat it may be hammered into various forms, or welded by the blows of the hammer to another piece of steel or iron. Blistered steel, rolled or beaten down into bars, forms SHEAR STEEL; and if melted, cast into ingots, and again rolled out into bars, it forms *cast steel*, which when well prepared has the great recommendation of perfect uniformity of texture, and a finer and closer grain. The peculiarity of steel, upon which its high value in the arts in great measure depends, is its property of becoming, if suddenly quenched in water, when at a bright red heat, extremely *hard*, and of being again *softened* down to any requisite degree by the application of a certain temperature, which may be indicated by a thermometer, commencing at about 300°, and terminating at a dull red heat. This process is often called *tempering*; and the workman is sometimes guided in the extent to which it is carried by the *colour* of the polished surface of the heated steel, which is at first rendered of a pale straw tint, then yellow, brownish purple, and blue, as the temperature rises from one extreme to the other. The latter colour indicates extreme softness and elasticity, such as belongs to watch springs, some sword blades, &c.; pale straw indicates great hardness, as for razor blades; yellow is somewhat softer, and shows a fit temper for penknives; and the incipient blues announce the temper that belongs to coarser cutting instruments, and to table knives, any of which, made of hard steel, would soon get spoiled and notched, but the edges of which, when duly tempered, resist breaking on the one hand, and bending on the other. When a large mass of steel is hardened by quenching in water, it undergoes a certain degree of expansion, so that the specific gravity of hard steel is somewhat less than that of soft. Attempts have been made to improve the quality of steel for certain purposes by adding to it small portions of other metals: hence the term *silver steel*, &c.; but none of these alloys have, on the whole, proved superior to well-made common steel. There is a kind of steel imported from India, known under the name of *wootz*, the cutting instruments of which are celebrated for the toughness and durability of their edge. It appears probable that its peculiarities depend upon the presence of a little aluminum. When the surface of some kinds of steel is washed over with a weak acid, it acquires a peculiar mottled or *damasked* appearance, as if its texture consisted of an intimate mixture of two different kinds of steel, or of fine fibres of steel and iron. Steel, alloyed with a little nickel, often puts on this appearance; but these and some other imitations of the celebrated *Damascus* sword blades have not led to any important improvements in the manufacture of our cutting instruments.

Steel Engraving. The art of engraving on steel. [ENGRAVING.]

Steel Guns. Since the introduction of rifled ordnance into the armaments of Europe and America, great endeavours have been made to obtain a material capable of withstanding the great strain to which rifled guns are subjected, and especial attention has been directed to steel.

In this country, guns entirely made of steel have not been adopted, but many of the service built-up guns have their inner barrels of steel. These barrels are not cast in the government works, but are obtained from private manufacturing firms in the form of cylindrical blocks, which are afterwards tempered, bored, and turned in the Royal Arsenal at Woolwich.

The process of manufacture of these blocks is as follows: Bars of blistered steel, made by the ordinary cementation process from wrought iron, which has been obtained by puddling without refining, are broken up into lengths of about five inches, and arranged according to quality. From them a mild steel is selected, containing but little carbon, and with small crystals. The pieces selected are placed with a little flux (oxide of manganese) in crucibles having tightly fitting covers, and are melted in air furnaces, heated with coke, below the floor of the foundry. Each crucible contains about 45 lbs., and is heated before being charged. A little glass, thrown in before the steel melts, forms an air-tight crust on the top of the metal, which latter takes about three hours to melt.

As soon as the metal is melted, the pots are lifted out, and run upon wheels to the mould, which is composed of cast iron coated with oil and black lead. The covers being removed and the crust broken, the metal is poured into the centre of the mould, a casting of six tons taking about 280 pots, and occupying about ten minutes in casting. The ingot is then allowed to cool gradually, and, when cold, the lower end, which is most dense, is marked for the breech, and about one-third of the ingot is cut off from the upper end. The ingot is now drawn out under a heavy steam hammer to the proper length, as much as possible by pressure, and not by sharp blows, which injure the metal, on which account hydraulic presses are coming into use for this purpose instead of hammers. This drawing out is performed at a moderate heat, which is acquired generally in a Siemen's regenerating furnace. When complete, the block is lacquered, and the ends are faced.

The block in this condition is sent to the Royal Arsenal, and there tested, when, if

accepted, it is tempered in the following manner: It is placed in an iron cylinder, and surrounded by a wood fire till brought to a dull red heat, when it is lifted out and dropped into another cylinder containing cold oil, where it remains till cold, the oil being kept cool by the constant flowing of a stream of water round the cylinder in which the oil is contained. By this process of tempering, the hardness and tenacity of the metal are increased, and its ductility and specific gravity decreased, probably by the free carbon becoming chemically combined, and the crystals of steel being thus fixed in their expanded state. The block is then bored and turned.

Although in our service these steel blocks form only the inner barrel of the gun, and are strengthened by shrinking on over them a series of wrought-iron coils in a state of initial tension, as explained in the article RIFLED GUNS, in many other countries solid steel guns are employed. The chief maker of these is Herr Krupp, of Essen, in Prussia, whose cast steel has attained such eminence, and has of late excited so much curiosity, that a sketch of the chief peculiarities of its manufacture, abridged from the *Report of a Professional Tour of Officers of the Royal Artillery in* 1865, may not be out of place here. Krupp's cast-steel guns have been adopted not only by Prussia, but to a considerable extent by Russia, Belgium, some of the minor German states, Austria, Holland, Italy, Egypt, Turkey, and even Japan. At the close of 1865, he had made upwards of 2,500 guns, 400 of which were of 8-inch calibre and upwards.

The ore employed in these works is partly obtained from Krupp's own mines at Nassau and Coblentz, and partly bought, the former being spathic, furnishing the well-known *spiegel-eisen*, the latter being red iron-ore, both smelted with coke. The greater proportion of the cast iron is brought into the form of puddled steel, but some is carried through to wrought iron, and a small quantity of cemented steel is bought. A modification of Bessemer's process is employed to convert some of the metal into wrought iron.

The metal of which guns are composed is a mixture of steel and wrought iron, melted in plumbago crucibles holding about 30 lbs. each, so small a quantity only being used, as this soft metal is difficult to melt and manage. The pots rest on loose bars in furnaces, and can only be used once, as the heat attained brings them to a state of incipient fusion. In the centre of the foundry is a pit containing the mould, and the reservoir, whose office is to secure a steady vertical flow of the metal into the mould. Troughs lead to the reservoir.

When the crucibles are taken out, the covers are not removed, but the metal is poured out through a hole in the upper edge into the nearest trough. Great care is taken, and wonderful perfection has been attained, in timing the movements, so as to keep the molten metal flowing in a continuous stream into the reservoir. As many as 400 men are employed in a cast of 16 tons. The cast is allowed to cool till it has shrunk sufficiently from the mould to be turned out, when it is surrounded by hot cinders, and kept hot (cherry red) till wanted for forging, sometimes for as long a period as three months.

For the sake of homogeneity, all castings are made cylindrical or square, and hammered to the rough shape required, which increases the density, strength, and elasticity. This hammering is continuous, the ingot being kept at the same temperature by frequent heats. When fully worked, the breaking strain of the metal used for guns is about 44 tons per square inch.

The smaller kinds of guns are fashioned from one solid piece; those above 8-inch calibre are compound, being weighted and strengthened by external rings. Th 11-inch gun, for instance, is cast as a solid cylinder weighing 35 tons, and of seven feet diameter, and is afterwards hammered out, and shaped, being turned down to a thickness over the charge of one calibre. The trunnion ring, which is also a cast-steel cylinder forged into shape, is shrunk on, and the breech strengthened by the addition of hoops of cast steel forged as above to a breadth of ten and a thickness of six inches. These guns are 16 calibres in length, and weigh 28 tons. A 15-inch gun is being made for the Russian government.

The largest hammer used in forging is one of 50 tons, with a fall of 10 feet. It is intended to erect one of 120 tons, with a drop of 13 feet, the estimated cost of which is 200,000*l.*

The only experiments made with Krupp's guns of large calibre have been carried on in Russia, and the results are embodied in a report presented to the emperor by a commission, including among its members General Todleben and other distinguished men. A 9·65-inch rifled muzzle-loading gun, weighing 148 cwt., with projectiles of 269 lbs. and a charge of 45 lbs. of prismatic powder (weaker than English common powder), burst at the 66th round. This was attributed to the wedging of the shot in the bore. An 8·58-inch gun, with charges of 33 lbs. and shot of 220 lbs., burst at the 109th round. It was rather heavier than the 9·65-inch gun. Four guns, all muzzle loaders, three of 8½ inches, and one of 11 inches, were then tested for endurance. Two of them, which were rifled, withstood, the one 215 rounds, the other 286 rounds, 46 rounds with each being fired with 33 lbs., the remainder with 27½ lbs. of powder. The other two were smooth bored, and withstood 1,025 and 790 rounds respectively with round shot and charges of prismatic powder about ⅙ and ¼ the weight of the shot. None of these four guns were fractured, but were all worn or eaten into at the seat of the shot by the gas, to such an extent that the committee considered that the service of these guns cannot with safety be assigned a higher duration than 250 rounds. The two guns which were fractured are reported to

have been of exceptionally good metal, uniform, homogeneous, and of great tenacity; but they evidently burst from overwork, the charges being excessive.

Such are some of the principal results as yet attained in the manufacture of steel ordnance. In comparing this metal with others, as a material for guns, there are several points to be considered. Putting aside cast iron as uncertain in tenacity and wanting in elasticity, and bronze as wanting in hardness and elasticity, and therefore unfitted for rifled guns to be fired with large charges, it may be desirable to glance at the comparative merits and defects of steel and wrought iron. The same drawback that exists to the employment of large forgings of wrought iron, viz. the impossibility of obtaining perfectly sound masses of metal, must evidently apply to any steel but cast steel; steel, however, can be melted at a practicable heat, and run into large masses, and so, if the casting be carefully carried out, homogeneity and soundness may be obtained. It also possesses the important advantages of greater elasticity, tenacity, and hardness.

Steel, however, though possessing a greater tenacity or ultimate cohesion than wrought iron, and a greater elastic limit within which no change of form will take place, does not possess between its elastic limit and its ultimate cohesion the same ductility or extensibility as wrought iron; so that, while the latter will stretch after its elastic limit is passed or overcome by sudden strain, steel will break and fly into destructive pieces—a fatal fault in a gun.

If it were possible to obtain a steel which with its great elasticity and tenacity would combine great ductility, the best cannon metal would be found. Some of the low steels or homogeneous iron, which by Kirkaldy's experiments were shown to have a considerable extensibility before fracture, seem to approach near to these qualifications. But, unfortunately, as the one valuable property increases, the other diminishes. *Low steel*, or, as it is called, *mild steel*, *soft steel*, or *homogeneous metal*, containing but little carbon, possesses greater elasticity and tenacity than wrought iron, with some extensibility; but *high steel*, containing more carbon, though more tenacious, hard, and elastic, is wanting in ductility to such an extent as to make it altogether too brittle for guns.

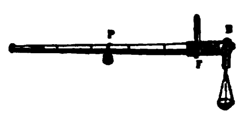
Unless, then, the manufacture of steel be improved, it seems that, if steel guns be used, such an excess of metal must be given to them as will add greatly to their power of resistance, and will render them capable of resisting high charges. But there is a limit, at which no addition of thickness to the exterior of a gun adds anything to its resisting power, and this is reached when the maximum pressure per square inch exerted on the interior equals the resistance of the metal at the point of rupture; for at this point the internal laminæ will tear asunder, and so outwards in succession, on further strain. Now, the thickness at which internal rupture will commence is inversely as the final extensibility; and the coefficient of extension of steel is so small that the thickness at which any further addition will be useless is soon reached. It remains only, then, to fire with small charges, such as will avoid all risk of overcoming the elastic limit of the metal.

Here we meet with this obstacle, that we have not yet succeeded in measuring in any way at all satisfactory the initial strains of various charges of powder fired under various conditions. Could this be done, we might accurately apportion the charge to the strength of the metal, which is capable of being ascertained. Till then we work in the dark, using empirical rules.

The other chief point to be taken into consideration is the great cost of steel, caused in the first instance by the expense of melting and casting, the careful selection of the material, &c. If the Bessemer process, which is based upon true principles, can be carried to greater perfection, this may be overcome in time; but the cost of turning and boring such a hard metal will always be very great.

How far steel tubes strengthened by external rings in a state of tension will stand, is still a question open to argument. Steel tubes are at present employed by the government authorities at Woolwich for the large muzzle-loading guns; but some guns will be constructed with barrels of Marshall's wrought iron, which is of most excellent quality. The steel tubes have shown a tendency to split; but if the charges have been excessive, this is only what must follow from the principles above explained.

Steel Yard. A balance by which the weights of bodies are determined by means of a single standard weight. The instrument, which is represented in the annexed figure, is a lever having unequal arms. The load, the weight of which is to be determined, is suspended from the extremity B of the short arm; and in weighing, the constant weight or counterpoise P is slid along the longer arm until the equilibrium is established. Divisions traced on this arm indicate the weight at B corresponding to each position of P.



In the Roman steel yard, or *statera*, the lever was so constructed that the centre of gravity was brought immediately over the point of support; and the system being accordingly balanced upon its fulcrum F, the effect of the weight of the lever was neutralised. The longer arm was then divided into parts, each equal to the shorter arm, and those again equally subdivided. Suppose now the length of the shorter arm, or the distance F B, to be one inch, and the constant weight P to be one pound; then if P be placed at the distance of five inches from F, it will make equilibrium with a load of five pounds suspended from B; for, from the

property of the lever, when the equilibrium is established, the weight P is to the load at B as the distance of B from F is to the distance of P from F. Whatever proportion, therefore, FP has to FB, the same proportion has the weight suspended from B to the constant weight P.

The steel yard in common use is constructed somewhat differently, the beam being seldom made so as to balance itself on the fulcrum F; but the error arising on this account is compensated by beginning the divisions at that point where the equilibrium is established, when the weight P is placed upon it. If, therefore, when P is removed, the longer arm preponderates, the divisions commence from a point between F and B. For the purpose of increasing the range, there are also in general two fulcra, from either of which the beam may be suspended, and two corresponding scales of division are marked on opposite sides of the longer arm.

For weighing heavy loads the steel yard is a convenient instrument; but for smaller weights it is susceptible of less accuracy than the common balance. It should be constructed so that the point of support F, and the point of suspension at B, may be in the same straight line with the divisions of the beam.

Steel Yard, Merchants of the. A company of London merchants to whom the STEEL YARD was assigned by Henry III. A.D. 1232. They were all foreigners, chiefly Flemish and German, and were long the only exporters of the staple commodities of England.

Steening or **Steining.** In Architecture, the brick or stone wall or lining of a well.

Steeple. In Architecture, a tower of various forms, usually attached to churches and other public buildings, in which bells are frequently, but not always, suspended.

Steer (Ger. steuern). To keep a ship on a given direction. This is done by moving the rudder by the tiller, which last is moved to the opposite side to that towards which the ship's head is required to proceed.

Steerage. The steering of the ship. Also a place below in the fore part of ships, as distinguished from the *chief cabin*; but the term is of uncertain acceptation.

Steganography (Gr. στεγανός, *covered*, and γράφω, *I write*). The art of writing in CYPHER.

Steganopods (Gr. στεγανόποδες, *web-footed*). The name of a family of swimming birds (*Natatores*) in the system of Illiger, including those species in which all the four toes are connected by the same web. It corresponds with the genus *Pelecanus* of Linnæus.

Steinerian of a Plane Curve. The locus of the intersections of the pairs of lines which constitute the polar conics of the curve; in other words, the locus of double points on all polar conics, or, what is the same thing, the locus of the *poles* of all first polars which possess double points. [POLES AND POLARS.] The locus of these double points on first polars is the Hessian, since by the law of reciprocity the polar conic of every such double point breaks up into two right lines. The Hessian and the Steinerian, therefore, are closely related; the polar conic of a point on the Hessian has a double point on the Steinerian, and the first polar of a point on the Steinerian has a double point on the Hessian. They were called conjugate *kerncurven* by Steiner (Crelle's *Journal*, vol. xlvii. 1854); the name Hessian was proposed by Sylvester (*Phil. Trans.* 1853), and that of Steinerian by Cremona (*Memorie dell' Istituto di Bologna*, t. xii. 1862). The Hessian is of the order $3(n-2)$, the Steinerian of the order $3(n-2)^2$. The Hessian passes through all the points of inflexion on the primitive curve, whilst the Steinerian touches all its stationary tangents. For cubics both curves coincide; a point on the Steinerian, and the double point on its first polar, then become *corresponding points* on the Hessian. [CUBICS.]

Steinheilite. A variety of Iolite, found with Copper Pyrites, at Orijerfvi in Finland. It is of a blue colour, and is considered by jewellers an inferior variety of Sapphire. Named after Count Steinheil.

Steinmannite. An impure variety of Galena. It is a double sulphide of lead and antimony, occurring in octahedrons, also massive, and in botryoidal and reniform aggregations of a lead-grey colour, at Przibram in Bohemia. Named after the chemist Steinmann.

Stela (Gr. στήλη, *a post*). In Architecture, a small column without base or capital, usually with an inscription to record an event, or to perpetuate the memory of some deceased person. Stelæ were also used for marking distances, and several specimens may be seen in the British Museum.

Stellatæ (Lat. *set with stars*). In Botany, a natural order of Exogens, also known under the name of GALIACEÆ.

Stelleria. A generic name given to an extinct northern *Manatee*, from its discoverer the Russian traveller and naturalist Steller: it is now more commonly called *Rhytina borealis*.

Stelleridans (Lat. stella, *a star*). Star fishes. The name of the family of Echinoderms of which the genus *Asterius* is the type.

Stellio (Lat.). The generic name given by Cuvier to those Iguanian lizards that have the tail girt by rings composed of large and sometimes spiny scales.

Stellionate (Lat. stellionatus). In the Roman Law, a general term comprehending all sorts of fraud committed in matters of agreement which were not designated by any more special appellation. The name is said to be derived from stellio, *a lizard*, because the fraudulent man may be compared with that animal for versatility and address. The six common species of stellionate enumerated by Roman writers were: 1. When one sells the same thing to two purchasers; 2. When a debtor pledges to his creditors something which does not belong to him; 3. When one abstracts or damnifies

something which he has pledged to creditors; 4. Collusion by two parties to the prejudice of a third; 5. When a vendor substitutes an object of less value for that which he has engaged to sell; 6. A wilful false declaration in an instrument.

Stellite (Lat. stella, *a star*). A white translucent variety of Scolezite, crystallised in concentric stellar groups of delicate rhombic prisms, at Kilsyth, Scotland, embedded in greenstone.

Stem (Ger. stamm). The ascending axis of a plant: that part of a plant which bears or has borne leaves or their rudiments; the upward axis of growth. It is sometimes subterranean, but more commonly exposed to the air and light.

Stem. In Music, the upright or downright line added to the head of a musical note; the head being that part filled in black or left open, as the case may be.

Stem. A strong timber, forming in a ship the wedge-like front. It is united by a scarf to the keel and rises nearly perpendicularly from it. The fore-ends of the planks of the side are firmly embedded in the stem. It is backed by the *apron* and *stemson*.

Stemless. In Botany, this term denotes the absence of a visible or obvious stem.

Stemples. In Mining, cross bars of wood in the shafts of a mine.

Stemson. [Stantion.]

Stencil. A piece of thin leather or oilcloth, used in painting on walls. The pattern, cut out of such pieces, is laid flat on the wall, and the colour is brushed over it.

Stenelytrans (Gr. στενός, *narrow*; ἔλυτρον, *a sheath*). The name given by Latreille to a family of Coleopterous insects, comprehending those in which the elytra become narrow at the posterior part of the body.

Stenography (Gr. στενός, and γράφω, *I write*). The art of short-hand, otherwise termed *tachygraphy*. This art has been practised from remote antiquity, and it is said to have originated in the hieroglyphics of the Egyptians.

Stentor. In the *Iliad*, a herald of the Achæans, whose voice was as loud as that of fifty men: hence the adjective *Stentorian*.

Step. A block of wood, or in large ships a strong solid platform, upon the keelson, supporting the heel of the mast, and spreading the pressure. It was found that the weight of the mast, yards, &c. added to the enormous force upon the rigging, especially during strong winds, forced the keel down.

Stephanite or **Black Silver-ore.** Native sulphide of silver and antimony, composed (when pure) of 70 per cent. of silver, 14 antimony, and 16 sulphur. It is a valuable ore of silver, of a dark lead-grey or iron-black colour, with shining metallic lustre, and is found associated with other silver-ores principally in Saxony, Hungary, Bohemia, and the Harz. Named after the Austrian archduke Stephen.

Steppes (Russ.). The name given to part of the low tracts of flat land in the northern parts of the Old World, traceable from the shores of the German Ocean through Holland and North Prussia into Russia, thence into Siberia, and so at intervals to the coast of the Pacific in Behring's Straits. The area is estimated at 4,500,000 square miles, a part of which is below the level of the ocean.

The parts of the plain strictly denominated *steppes* begin at the river Dnieper and extend along the shores of the Black Sea, including all the country north and east of the Caspian and the low lands of Siberia. Hundreds of leagues may be traversed eastwards of the Dnieper without variation of scene, and there is a dead level of thin but luxuriant pasture, bounded only by the horizon. While vegetation lasts, there are horses and cattle without number; but winter begins in October and the whole area is then covered with snow. Fearful storms of wind often rage when the sky is clear and bright. In June, the steppes are parched and the air is filled with dust; but at other times, and in many parts, wheat is cultivated, and the crops obtained are very large. On the whole, however, the steppes must be regarded as barren, and part of the tract is even a desert. Between the Caspian Sea and the sea of Aral there is for the most part a wide ocean of shifting sand, often driven by whirlwinds. [Aralo-Caspian Region.]

Stercorianism (Lat. stercus, stercoris, *refuse*). In Ecclesiastical History, a nickname which seems to have been applied in the Western church, in the fifth and sixth centuries, to those who held the opinion that a change took place in the substance of the consecrated elements, so as to render the divine body subject to the act of digestion.

Stercorite (Lat. stercus). An ammonio-phosphate of soda, occurring in crystalline masses and nodules in the guano of Ichaboe, on the west coast of Africa.

Sterculiaceæ (Sterculia, one of the genera). A large order of hypogynous Exogens belonging to the Malval alliance. They have the valvate calyx, contorted petals (sometimes wanting), and monadelphous stamens of *Malvaceæ*, but differ from them in their anthers being always two-celled. They consist of tropical South African or Australian herbs, shrubs, or trees, with alternate entire lobed or digitately compound leaves, furnished with stipules, and produce axillary or rarely terminal flowers, which are often large and handsome. The order has been variously extended or broken up into smaller ones by different botanists. Some include the *Bombaceæ*; but others refer these latter to the *Malvaceæ*, as having always one-celled anthers, and combine the *Byttneriaceæ* with *Sterculiaceæ*, dividing the order thus constituted into seven tribes: *Sterculieæ* proper—trees or shrubs, with unisexual flowers, no petals, five to fifteen anthers, adnate to the top of the column, and carpels distinct when in fruit; *Helictereæ*—trees or shrubs with hermaphrodite flowers, five petals, five to fifteen

anthers, singly or by twos or threes alternating with the teeth or lobes of the staminal column; *Eriolaneæ*, *Dombeyeæ*, *Lasiopetaleæ*, *Hermannieæ*, and *Byttnerieæ*, the latter group being frequently separated as the order *Byttneriaceæ*.

Sterelminthans (Gr. στερεός, *solid*, and ἕλμινς, *an intestinal worm*). The name of a class of internal parasitic animals or Entozoa, comprising those which are composed of a solid parenchymatous substance, in which the nutrient and generative canals are simply excavated, and not freely suspended in an abdominal cavity.

Stereo-electric Current. A term now rarely applied to the *thermo-electric* current which ensues when certain metals are brought into contact at different temperatures; it implies the production of a current of electricity in *solid bodies*, as opposed to the voltaic or *hydro-electric* current, in which fluids are essential.

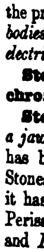
Stereochrome Painting or **Stereochromy.** [WATER-GLASS.]

Stereognathus (Gr. στερεός, and γνάθος, *a jaw*). A genus of fossil mammalia, which has been discovered in the Middle Oolite, at Stonesfield. From the appearance of teeth, it has been inferred that it belonged to the Perissodactyle series, allied to *Hyracotherium* and *Pliolophus*, but it is of small size, and its exact position in the scale is not yet definitively ascertained.

Stereographic Projection. [PROJECTION OF THE SPHERE.]

Stereography. In Descriptive Geometry, the representation of solids on a plane.

Stereometer (Gr. στερεός, and μέτρον, *measure*). In Hydrodynamics, an instrument invented by M. Say, a French officer of engineers, for determining the specific gravity of liquid bodies, porous bodies, and powders, as well as of solids. The instrument may be



described as follows: Let A E be a glass tube, about three feet long, and open at both ends, the upper part A B being about $\frac{4}{10}$ and the lower $\frac{2}{10}$ of an inch in diameter. The upper edge is ground smooth, so that it can be shut air-tight by a piece of ground plate glass; and the upper part A B communicates with the lower by a very narrow slit at B, which allows air to pass, but prevents the passage of sand or water. In using the instrument, a powder (for instance) is placed in the tube A B, and the lower part B E is plunged into a vessel containing mercury till the fluid rises exactly to B. The ground glass cover is then placed upon the mouth A, and there is now no air in the tube except that which is mixed with the powder. Supposing the barometric pressure to be thirty inches; let the tube be elevated until the mercury stands within it at a point C, fifteen inches above its surface in the open vessel, and it is manifest that the air within the tube is pressed with exactly half an atmosphere. It consequently expands to twice its original bulk, and hence the tube A B now contains only half the quantity of air which it contained at first. The part B C must therefore contain the other half, or the air in B C is equal to the air mixed with the powder in A B; and being half the original quantity under half the original pressure, it fills the same space which the whole occupied previous to the expansion. Let the powder be now removed from A B, and the process repeated when the tube is filled with air. The quantity of air, being now greater, will, when expanded to twice its bulk, fill a larger space than B C, and the mercury will rise only to some point D; but as the expanded air occupies exactly the same space in B D or B C as the whole occupied in A B under twice the pressure, it follows that the cavity $CD = BD - BC$ is equal to the bulk of the solid matter in the powder. If, therefore, we now find the number of grains of water which would fill the part C D, we determine the weight of water equal in bulk to the solid matter in the powder; and by comparing this with the weight of the powder, we obtain its specific gravity. [HYDRODYNAMICS.]

Say's stereometer was first described in the *Annales de Chimie* for 1797. An instrument on exactly the same principle was afterwards brought forward by Sir John Leslie under the name of a *coniometer*. Although this instrument is simple and exact in principle, it could not in practice yield accurate results, without extraordinary precautions, on account of the great alterations in the bulk of the included air, caused by variation of temperature and even of barometric pressure during each experiment.

Stereoscope (Gr. στερεός, and σκοπέω, *I view*). The name given by Prof. Wheatstone to an instrument or apparatus proposed by him, and described in a paper on the Physiology of Vision, published in the *Philosophical Transactions* for 1838, for the purpose of exhibiting the effect of simultaneously presenting to each eye the projection of a solid body on a plane surface as it appears to that eye. To render this clear, it may be necessary to remark, that when a body of three dimensions is placed so near the eyes that, on looking at it, the optic axes must converge, a different perspective representation of it is seen by each eye; the body being, in fact, thus seen from two points of sight, at a distance from each other equal to the distance between the centres of the pupils, and the pictures of it projected on the two retinæ being consequently dissimilar. Supposing, then, two perspective drawings, on a plane surface, to have been made of an object as it is seen by each eye respectively; in order to try the experiment, it is necessary that the pictures be placed so that each can be seen by one eye only, and that the rays of light from the corresponding points of the two pictures fall on similar points of both retinæ, or enter the eyes in the same directions with the rays from the corresponding points of the original object. By reason of the small distance between the two eyes, this, manifestly, cannot be done without altering the direction of the rays.

For this purpose, Professor Wheatstone employed two small plane mirrors, about four inches square, adjusted at right angles to each other so as to form two adjacent sides of a cube, the faces being outwards. The edge where the two planes meet being brought close to the face of the observer, and the mirrors being placed symmetrically with respect to the direction of the visual rays, it is evident that if the two pictures be respectively placed before the mirrors symmetrically, and at equal distances, rays of light proceeding from them in opposite directions, and falling on the mirrors, will be reflected at right angles to their former directions, and become parallel. The right eye will see only the reflexion of the picture on the right-hand side, and the left eye that on the left-hand side; but on regarding both simultaneously, the mind readily unites the two images, and instead of the two plane pictures, an object of three dimensions makes its appearance, the exact counterpart of that from which the pictures were drawn standing out, as it were, in relief between the planes of the two mirrors.

In the *Report of the British Association for the Advancement of Science*, for 1849, Sir David Brewster states that, having had occasion to make numerous experiments on this subject, he was led to construct the stereoscope in several new forms. Of these forms, the most generally useful is the *lenticular stereoscope*. This instrument consists of two semilenses placed at such a distance that each eye sees the picture of a drawing opposite to it, through the margin of the semilens, or through points of it equidistant from the margin. The distance of the two portions of the lens through which we look must be equal to the distance of the centres of the pupils, which, at an average, is two and a half inches. By this method the images are not only united, but magnified at the same time, which is in many cases advantageous. The stereoscopes now so commonly used for viewing photographs taken from two different points of view are constructed on this principle.

Stereotype (Gr. *στερεός*, and *τύπος*, *an impression*). The surface of a page of types cast in one piece of type metal, about an eighth of an inch in thickness. The best kind are cast from a plaster mould, in which an exact representation of the types has been made, thus forming the permanent plates from which books are afterwards printed. As the art of PRINTING began with the impression of whole blocks, it may be said that in its progress towards perfection it has again reached the same point by the introduction of stereotype plates. The origin of the more modern invention is involved in greater obscurity than might at first sight appear probable from its comparatively recent date. By some writers the merit of the invention is ascribed to the Dutch, who had adopted the plan of printing with solid or fixed types in the seventeenth century; but it was not till the end of the last, and the commencement of the present century, that the process was perfected and generally introduced. In this useful invention, the most prominent names are Ged of Edinburgh, Tulloc and Foulis of Glasgow, Didot in Paris, and Wilson and Earl Stanhope in London.

Plaster of Paris Process.—The process of stereotyping by this process is very simple. A page of any work proposed to be stereotyped is set up with movable types, in the ordinary way. A plaster cast is then taken from it, which, being first dried, is immersed in fluid metal. The plaster used for forming the mould is pulverised gypsum, mixed with water to the consistence of cream. Lord Stanhope says, 'The best burnt gypsum mixes the most conveniently in the proportion of seven parts of water to nine of gypsum.' After the form of types has been surrounded with a brass frame, and slightly oiled on the surface, the fluid plaster is poured upon it, and, by the application of a brush, made to fill every cavity of the letters, the superfluous portion being scraped off. When the plaster has set sufficiently hard, it is by means of the frame lifted off the face of the type and detached from it. It is then baked to dryness in an oven; and when quite hot it is placed in an iron box or casting pot, which has also been heated in an oven. The box is now plunged into a large pot of melted type metal, and kept about ten minutes under the surface, in order that the weight of the metal may force it into all the finer parts of the letters. The whole is then cooled; the mould is broken and washed off; and the back of the plate turned smooth on a lathe, or planed by a machine. The cast or plate, after being sufficiently cooled, is carefully examined with a view to removing any imperfections previous to its being printed from.

Papier-mâché Process.—In stereotyping, a new method has of late years been introduced from Paris. On the face of the type is laid a mould consisting of six or seven sheets of fine tissue paper, gummed together and moistened; the outside sheet being of a stouter paper. The whole is then struck regularly and carefully with a large flat brush of hard bristles, till the moistened paper has received an impression of the type, &c. beneath. The mould is then dried on a hot iron table, a blanket being laid over it to absorb the moisture, and screwed down moderately tight to prevent it from warping. When sufficiently dry, which it becomes in a very few minutes, it is ready for the stereotype cast. This is taken in an ingeniously contrived mould, by which the size and thickness of the plate, whatever they may be, are regulated. The mould has not then to be destroyed, as in plaster casting, but is removed, either to reproduce other casts immediately, or to be reserved for future use. This is of great advantage in the case of cheap publications or rough works of which reprints are often required, as

the moulds are light, and involve no expense in keeping.

Newspaper Stereotyping.—The stereotyping process by which the rapid printing of newspapers is effected is an improvement hardly inferior to that by which the late Mr. Walter applied steam power to the printing press, and certainly equal to that by which the rotary press superseded the reciprocating action of the flat machine. It was commenced, and has been elaborated to the point now reached, by the present Mr. Walter, at the *Times* office. He began his experiments, aided by an Italian founder named Dellagana, in 1856, when, by papier-mâché matrices, rapidly dried and placed in a mould, columns were cast in stereotype metal, type high, planed flat, and finished with sufficient speed to get up the duplicate of a form of four pages, which was worked off on a spare flat machine—the speed at which the *Times* had previously been published being thus accelerated by nearly 5,000 impressions per hour. The next step taken was to adapt these type-high columns to the Applegath presses, then worked with polygonal chases. That step raised the previous 5,000 to 10,000 per hour; but though the publication of the *Times* was thus finished in much less time than before, it soon became clear that the process could be greatly simplified in its details, and extended and improved in its application. Accordingly, shortly after the introduction of Hoe's machines, instead of dealing with separate columns, the papier-mâché matrix was taken from the whole page at one operation by beating in the matrix with brushes. The matrix, rapidly dried on heating surfaces, was then accurately adjusted in a casting machine curved to the exact circumference of the main drum of the machines, and fitted so as to secure a casting, as nearly as possible, of uniform thickness. On pouring stereotype metal into this mould, a curved plate was obtained, which after undergoing a certain amount of trimming at two machines, specially made for the purpose, one for squaring the plate while being picked, the other for planing the back, could be taken to press and set to work within twenty-five minutes from the time at which the process began. A still further improvement has been made at the *Times* office, by which less injury is occasioned to the type than by the process of beating in the matrix with brushes, saving the serifs of the letter from being broken, and giving a more uniform face to the plate; viz. by the use of roller presses, somewhat similar to an iron copperplate press. The printing obtained from these plates was as good as that from pages of movable type. All the risk, and inconvenience, and wear and tear attending the imposition of these pages in curved chases—the placing them on the presses—and subjecting them to the destructive friction of the machining process—were at once obviated. The fount, instead of wearing out every two years, might last for several, the present fount having been in use nearly seven years. The plates after doing their work for one day could be melted down the next into a new impression, and (most important of all) the original type page, safe itself from all chance of injury, could be made to yield any number of copies that might be required by the exigencies of the circulation, and which there were spare machines to work. Thus has it come about that the inner or news sheet of the *Times* is now printed every morning—stoppages included, at the rate of 52,000 impressions per hour—the two American machines yielding 16,000 each, and the two Applegath 10,000 each. Between three and five o'clock every morning there are cast and finished in the foundry of the *Times* office, four complete sets of each page of the news sheet—i. e. a quadruple of the eight pages—or thirty-two pages in all. Mr. Walter has applied steam power to the operations of the foundry, which, though still capable of considerable improvement, are now accomplished with great ease and certainty of result. It is obvious that by the multiplication of stereotype plates and machines there is practically no limit to the number of copies of a newspaper which might be printed within the time the process now usually occupies.

Sterlet. A small kind of sturgeon, the *Acipenser Ruthenus* of Linnæus. The larger kind occasionally taken in Britain is the sturgeon proper, *Acipenser Sturio*, &c.

Sterling. The legal description of the English current coin, of which the most probable derivation is from *Easterling*, the popular name of the Baltic and German traders who visited London in the middle ages; but in what manner it came to be so applied is unknown. Camden attributes it to the employment of German artists in coining. The silver penny was first called Easterling.

Stern (A.-Sax. steor-ern). In Naval affairs, the after extremity of a vessel.

Stern-post. An upright timber rising almost at a right angle from the after end of the keel, into which it is tenoned. It forms the after end of the ship, receiving the buts of the planking and being that part to which the rudder is usually hung.

Sterna. A genus of web-footed birds, having a bill as long as or longer than the head, almost straight, compressed, and pointed; the mandibles of equal length, the upper one slightly inclined towards the point; nostrils pierced towards the middle of the bill; legs small, naked to above the knee; three anterior toes, united by an indented web; the hind toe free; wings very long and pointed; tail more or less forked. From the two latter characters, the species of *Sterna* are sometimes called *sea swallows*: their proper English name is *tern*.

Sternbergite. Flexible sulphide of silver and iron, composed of 30·38 per cent. of sulphur, 34·18 silver, and 35·44 iron. It generally occurs in implanted rhombic crystals, which are attached to the matrix laterally, so as to form rose-like or fan-like aggregations; also massive. It is of a pinchbeck brown colour, with a violet-blue tarnish; is very sectile, and flexible in thin laminæ, which after being bent may be

smoothed down again with the nail, like tin-foil. It is found in Bohemia, Hungary, and Saxony. Named after Count Caspar Sternberg.

Sternoxi (Gr. στέρνον, *the breast*, and ὀξύς, *pointed*). The name of a tribe of Coleopterous insects, comprehending those in which the sternum is prolonged into a point at both extremities.

Sternson. A timber bearing the same relation to the stern-post which the stemson bears to the stem.

Sternum (Gr. στέρνον). In Comparative Anatomy, the simple or compound bone which completes the thoracic cage anteriorly, and serves as a medium of union to a greater or less number of the ribs. The sternum is not present in the skeleton of Fishes, Amphibians, or Ophidians. In Saurians, the anterior portion is generally expanded, to be joined to the broad coracoids and clavicles. In Chelonians, this part of the skeleton is remarkably developed, and very complex, and constitutes the greater part of the plastron or floor of their defensive osseous case. In Birds, also, it is more or less complex at the beginning of its developement; but the different ossifications are soon blended together, and form a single broad bone, principally remarkable for the keel-like process developed from the middle line of its under surface. This keel is subservient to the attachment of the muscles of the wing, and bears a direct proportion to the powers of flight; except where the wings, as in the penguin, are used as fins. In the Struthious birds, the keel of the sternum is wanting.

In Mammalia, the sternum is generally simple, and consists of a single chain of ossicles; except in the orang-utan, and occasionally in man, where a double series of ossifications are originally developed in the body of the bone, but which afterwards become confluent. The upper portion, or *manubrium sterni*, remains long distinct from the main body of the sternum; in man, the cartilaginous appendage of the lower edge of the sternum is called *xiphoid* or *ensiform*.

Stethoscope (Gr. στῆθος, *the chest*, and σκοπέω, *I explore*). A cylinder of cedar wood or other material, about twelve inches long, and one inch in diameter; perforated throughout its length. It is occasionally divided into two parts for the convenience of using the whole or half its length. The end of one part terminates in a funnel-shaped cavity; the other end, which is applied to the ear during auscultation of the chest, varies in shape according to the fancy of the physician. It is usually in the form of a disc, more or less hollowed out and rounded at the edges to receive the ear conveniently. One great use of this instrument consists in its allowing the auscultator to examine over small portions of lung at a time, and so detect more correctly than by the naked ear the exact part or parts affected by disease. [AUSCULTATION.]

Stevedore or **Stivadore.** In Merchant Shipping, the officer whose business it is to superintend the stowage of ships. Maclachlan, in his *Laws of Merchant Shipping*, says that the *Consolato del Mare*, an ancient collection of maritime laws, mentions an officer called *stibador* (Lat. stipator, *an attendant*), from which the English term is probably taken. Young's *Nautical Dictionary*.)

Steward. In Feudal Law, the lord's deputy or seneschal in the MANOR COURT, who presided over the business transacted in the court.

STEWARD. On Shipboard, a petty officer charged with the details of the preparation and arrangements of the officers' mess.

Steward, Lord High. The Lord High Steward was anciently the first officer of the crown in England, with the Latin title of Magnus Seneschallus. The office was at one period annexed to the lordship of Hinckley, in Leicestershire, held by the family of De Montfort; but on the fall of that noble house, it was in effect abolished as a permanent dignity, and is now only revived pro hâc vice on the occasion of a coronation, or the trial of a peer. In the former case, the lord high steward's commission is to settle matters of precedence, &c.; in the latter, to preside in the House of Lords.

In accordance with the feudal theory, the whole of England, as respected the crown, was treated as one great manor, the lord of which was the king; the great peers constituted the court baron; the lord high steward was the seneschal. Just as in the manor court, the initiative in a criminal or civil action could not be taken except on the presentment of the homage, or in the view of frankpledge, so no judgment against a peer could be instituted except by the action of the peerage. And, similarly, as in a manor court the proceeds or profits of fines and forfeitures became the right of the lord, so the offence of a peer resulted in a forfeiture to the crown. And again, as in the case of private manors, the loss of the high jurisdiction ensued from the necessity of pleading the privilege of the manor, and the ordinary police of the manor has fallen into desuetude from the same reason, so the house of peers has retained its special jurisdiction over its members, by virtue of the fact that parliament is itself a court of record of the highest kind, and therefore its jurisdiction could neither be forgotten, ignored, nor disputed. Judgment, in short, by peers did not originally mean the impanelling of a petty jury before a justice in eyre, but the right which every freeholder had, and, before long, every villein, of a legal trial before the jury of the manor in which he lived or his land was situate, or the offence with which he was charged was committed.

As might be expected, the steward's judicial functions have lasted longer in corporations than in any other localities. The successor of the steward in ordinary or municipal corporations appears to be the recorder; but the two universities have still each their high steward,

who is empowered to try felonies committed by privileged persons, and probably on privileged persons, within the verge of the academical liberties; and as the chancellor of the university answers to the lord of the ordinary manor, so the seneschal or high steward is his deputy, and appointed by him.

Steward, Lord, of the Household. An officer of the sovereign's household in England; in Norman French, *seneschal*. The principal officers of the lord steward's department are the treasurer of the household, the comptroller of the household, the master of the household, and the secretary of the *board of green cloth*, a body composed of the above-mentioned officials, who formerly exercised jurisdiction of offences committed within the verge of the court, but whose duties are now confined to the supervision of the household accounts, the government of the household servants, &c. The lord steward was the nominal head of the Court of the Marshalsea and the Palace Court until their abolition.

Steward of a Manor. In Law, the lord's deputy, who transacts all legal business in connection with the estate, and has custody of the court rolls. [COPYHOLD; MANOR.]

Sthenic Diseases (Gr. σθένος, *strength*). Those diseases which are the result of inflammatory or increased action; as opposed to asthenic, or diseases of debility.

Stibethyl. A combination of one atom of antimony and three of ethyl. It may be regarded as ammonia in which the nitrogen is replaced by antimony and the hydrogen by ethyl.

Stibiconise (Gr. στίβι or στίμμι, and κόνις, *powder*). A hydrated antimonious acid, which occurs in amorphous earthy masses of a yellow, grey, or brownish colour at Trewinnick, near Endellion, in Cornwall, and in various foreign localities.

Stibium (Lat.). Antimony. [STIBNITE.]

Stiblite. [STIBICONISE.]

Stibnite (Lat. stibium). Native tersulphide of antimony; composed, when pure, of 72·88 per cent. of antimony, and 27·12 sulphur. It usually occurs in long prismatic or acicular crystals, or in a fibrous form, of a lead-grey colour inclining to steel-grey, and sometimes with an iridescent tarnish. It is found in Cornwall, Cumberland, Scotland, and in several foreign localities, and is the ore from which most of the antimony of commerce is obtained. For the uses to which it was applied by the ancients, see Bristow's *Glossary of Mineralogy*, p. 362-3.

Stichomancy (Gr. στίχος, *a line*; μαντεία, *prophecy*). [SORTES.]

Stick, Gold. The colonels of the two regiments of Life Guards are so called, whose duty it is to be in immediate attendance on the sovereign on all state occasions. These colonels do duty for a month alternately; the one on duty being called the *gold stick in waiting*. The field officer of the Life Guards who is on duty is called *silver stick*. The term originated in the custom of the sovereign presenting the colonel of the Life Guards with a gold stick on his receiving the regiment.

Stigma (Gr. *a mark*). An impression such as that made by branding with a hot iron. Stigmatising was a common practice among the ancients to mark their slaves as property; and it is pursued at the present day among slave-drivers. It was customary also to stigmatise the votaries of some of the gods with some recognised emblem of their divinity, such as the ivy of Bacchus, the trident of Poseidon, &c.; or with the initial of their names, or some mystical number. It is supposed that reference is made to this practice in Rev. xiii. [TATTOOING.]

STIGMA. In Botany, the upper extremity of the style without a cuticle, in consequence of which it has almost uniformly a humid and papillose surface. It is the part upon which the pollen, when it falls thereon, is stimulated into the production of the pollen tubes, which are indispensable to the act of impregnation.

Stigmata (Gr.). In Theological language, the marks of the wounds of Jesus on the cross. The text at the end of the Epistle to the Galatians, 'From henceforth let no man trouble me: for I bear in my body the marks of the Lord Jesus,' seems to have given rise to the notions promulgated in the Roman Catholic church respecting the impression of the stigmata on favoured saints; of which the legend of St. Francis of Assisi affords the most remarkable instance.

Stigmite. [ST. STEPHEN'S STONE.]

Stilaginaceae (Stilago, one of the genera). A name originally proposed by Agardh for a small group of genera, including *Antidesma*, whose affinities had been little understood. Lindley places them as an order of Diclinous Exogens, in the Urtical alliance. By others they have been included in the large order *Euphorbiaceæ*, an arrangement which appears to be generally adopted.

Stilbaceae (Stilbe, one of the genera). A small order of monopetalous perigynous Exogens, whose immediate affinities are very uncertain. The order is usually placed near *Verbenaceæ* and *Selaginaceæ*, but Lindley regards it as more nearly allied to *Diapensiaceæ*. It consists of South African shrubs, with small crowded heath-like leaves, sessile unsymmetrical flowers in dense terminal spikes, a simple stigma, axile placentæ, and definite erect seeds.

Stilbene (Gr. στίλβω, *I shine*). A peculiar hydrocarbon, which crystallises in scales of a pearly lustre.

Stilbite. An anhydrous lime-oligoclase, composed of 58·2 per cent. of silica, 16·1 alumina, 8·8 lime, and 16·9 water. It generally occurs in broad prismatic crystals, clustered into sheaf-like aggregations and diverging groups; also massive and in fibrous aggregates. It is white, but sometimes yellow, grey, red, or brown, with a vitreous lustre, and is translucent to transparent at the edges. The principal localities in the United Kingdom are Cornwall, between

Botallack and Huel Cock; Isle of Arran, in granite; Campsie and Fintry, Stirlingshire, in porphyritic amygdaloid; in Ireland, at the Giant's Causeway, in geodes; Mourne Mountains in granite.

Stilbite is called by the German mineralogists *Desmine*; the mineral termed by them Stilbite being the *Heulandite* of English mineralogists.

Still (Lat. stillare, *to drop*). An apparatus for the distillation of liquids upon the large scale. It includes the *body*, or *boiler*, which is usually set in brickwork over a furnace, and to which is annexed the *head*, forming the communication between the boiler and *condenser* or *worm pipe*; from the extremity of which the distilled liquid passes in successive drops, or a small continuous stream, into the *recipient*. There are an infinite variety of stills adapted to particular purposes, of which the most important are the distillation of spirituous liquors. (Ure's *Dictionary of Arts, &c.*)

Still Life. In Painting, dead game, arranged fruit or flowers, silver, glass, china, and, in fact, any inanimate or *still* object.

Stillingia (after Benjamin Stillingfleet). A genus of *Euphorbiaceæ*, of which the Tallow-tree, *S. sebifera*, is the best known representative. This tree is a native of China and the adjacent islands, but has been introduced into and partly naturalised in India and the warm parts of America. It has rhomboid leaves with two prominent glands at the point of attachment between the stalk and leaf; and its flower-catkins are from two to four inches long. Its fruits contain three seeds thickly coated with a fatty substance which yields the tallow. This is obtained by steaming the seeds in large caldrons, and then bruising them sufficiently to loosen the fat without breaking the seeds, which are removed by sifting. The fat is afterwards made into flat circular cakes, and pressed in a wedge-press, when the pure tallow exudes in a liquid state, and soon hardens into a white brittle mass. This tallow is very extensively used for candle-making in China; but as the candles made of it become soft in hot weather, they generally receive a coating of insect-wax. A liquid oil is obtained from the seeds by pressing. The tree yields a hard wood used by the Chinese for printing blocks, and its leaves are employed for dyeing black.

Stilpnomelane (Gr. στιλπνός, *shining*, and μέλας, *black*). A hydrated silicate of alumina and protoxide of iron, which occurs in blackish-green masses, with a granular or radiating and foliated structure in the clay-slate of Zuckmantel in Austrian Silesia.

Stilpnosiderite (Gr. στιλπνός, and σίδηρος, *iron*). A hydrated peroxide of iron, referred by Ullman to Limonite, and by Von Kobell to Göthite. It occurs massive, or in stalactitic, botryoidal, and dendritic forms, varying from blackish-brown to pitch-black, at Tincroft in Cornwall, and in Saxony, the Harz, Bavaria and Siegen in Prussia.

Stilt Bird. The name of the *Himantopus melanopterus*, significative of its very long and slender legs.

Stimmi (Gr.). An ancient name of the sulphide of antimony. [STIBIUM.]

Stink Wood. The useful timber of *Oreodaphne bullata*, which possesses a durable and most unpleasant odour.

Stinkstone. A bituminous carbonate of lime, which exhales a fetid smell, like that of sulphuretted hydrogen gas, when rubbed or crushed. The limestones of the Purbeck and Portland formations of Dorsetshire, and the Mountain Limestone of Matlock, the Bristol Coalfield, and Sunderland, are examples of this kind of stone. It is stated by Prof. T. B. Jukes (*Manual of Geology*, 2nd edition, p. 145), that 'some of the limestone quarries in the Carboniferous Limestone of Ireland may be smelt at a distance of a hundred yards, when the men are at work.'

Stint. In Coal Mines, a measure of work used under ground, 2 yards long and 1 broad, which each miner clears before he removes to another place, and which is proved by a boy appointed for the purpose, who is colloquially called *the judge*.

Stipend (Lat. stipendium). This word signified originally the pay of soldiers. In a legal sense, it is applied to the salary or allowance given to some person for transacting the business of another; but in Scotland the term is almost exclusively confined to the provision made by law for the established clergy. [PRESBYTERY.]

Stipes (Lat. *the trunk of a tree*). In Botany, the stalk of a fern leaf; also the stem which supports the pileus in such fungi as Agarics.

Stippling. In Engraving, the method of producing shadows by means of dots of greater or less size, according to the intensity of shadow required. By this method the resemblance to chalk drawings is produced.

Stipule (Lat. stipula, *a stem of corn, stubble*). In Botany, a small appendage situated upon each side of the base of a petiole, most commonly of a less firm texture than the latter, and having a subulate termination. The word is also used in describing *Hepaticæ*, to denote the appendages which are occasionally present at the bases of the leaves, but of which they seem rather to be lobes than distinct organs.

Stirrups (A.-Sax. stige-rapa). On Shipboard, short ropes, pendent from the yards, and having eyes through which the horse passes, on which the sailors stand, when furling or unfurling the sail.

Stivadore. [STEVEDORE.]

Stiver. A Dutch coin, of the value of an English halfpenny.

Stoat. In common use, a synonym of *weasel* (*Putorius vulgaris*), but by British zoologists restricted to the larger variety, with a tendency to turn white in winter, at which season, in colder climates, it affords the valuable fur called *ermine*. By some this is held to be a distinct species (*Putorius erminea*).

Stock. In the phraseology of Agriculturists, the animals maintained on the farm are called *live stock*, the implements and carriages *dead stock*. This distinction is very ancient, being familiar to those who study mediæval records under the names of *staurum vivum* and *staurum mortuum*.

The amount of live stock which can be maintained on a farm is a question of great interest to the farmer, and must be determined by the peculiar character of the land which he cultivates, though of course it is possible by high farming, and especially by farming on lease, to increase the number of animals kept. But it is also of great importance to the public to know what is the ordinary amount of stock kept in the country, for its plenty or scarcity determines the supply of meat. Up to the present year (1866) no information on this subject has been supplied from Great Britain, though statistics have been given from Ireland for some years past. The returns which have been given this year were almost necessitated by the compensation clauses of the Cattle Plague Act. These compensation clauses were not defensible on grounds of common justice, for the losses of those whose cattle perished were more than countervailed by the rise in the price of those which survived, in accordance with a law noticed in the article Price, but they would have been utterly intolerable had there not been a statement of the proportion which the deaths by plague bore to the existing states. The numbers of the cattle kept in each European community of importance and in the United States are given below. The population and the returns of live stock are taken from the latest returns.

The table of statistics giving information of the amount of cattle, sheep, and pigs on March 5, 1866 (on the presumption that the returns are accurate), is singularly instructive. In drawing any inference on this subject, we should treat Great Britain separately from Ireland, as the importation of cattle from this part of the United Kingdom is more difficult than it would be from Belgium or France, and nearly as difficult as from Denmark and the Elbe. In round numbers, the population of Great Britain is about 24,000,000.

In one particular only, that of sheep, is Great Britain on a general level with other countries. There is nearly a sheep to every head of population. But of horned cattle there is only one to about every five; of pigs, only one to every nine. Were the amount of horned cattle in France proportionate only to that of Great Britain, France would have a little more than 6,000,000; in fact, it has rather more than 14,000,000. The same may be said of Austria. In many of the German states the proportion is higher still. In Denmark the cattle are not very much less numerous than the population. In the United States there is rather more than one head to every two of population. In France and Prussia, pigs are one to seven; in Austria, one to four and a half. Taking the whole of Europe, the proportion is one to six. In the United States there are more pigs than population.

Had the returns supplied us with information as to poultry, the deficiency of Great Britain would have been still more striking. In the year 1865 this country imported more than 400,000,000 eggs, if the hundred of eggs be taken, as it has been from the earliest time, at 120.

This deficiency is not greatly supplemented by importation. Small as the stock of cattle is, the annual importations do not amount to more than one-twentieth of the ordinary stock, while that of sheep is, as a rule, but one-fiftieth. During the present year even these quantities must have undergone a serious diminution. Nor is the import of meat large. The most important item is that of bacon. But even here the largest estimate will not give more than the equivalent of 300,000 pigs. The beef seems to be about equal to the supply of 50,000 oxen.

It is a matter of regret that no facts have been collected by which we might compare the past and present supply of live stock in Great Britain. It is, of course, always dangerous to trust to impressions, or to memory; but we cannot but be convinced that there has been a general and considerable diminution in the amount of live stock in Great Britain for some years past. It is now comparatively seldom that agricultural labourers are able to keep pigs; it is still more rare that they breed poultry. The enormous importation of eggs suggests that the fowls kept in Great Britain are comparatively scanty. But it is probable that the maintenance of insect-eating birds is an important provision in agricultural economy, and that when we find fault with the destruction of small birds, we forget that our practice is dispensing with a still more important means for checking the ravages of insects, as well as for supplying that great deficiency in live stock which seems to characterise our domestic economy. It is possible, too, that the abandonment of much pasture in the northern part of the island to deer forests and grouse moors has considerably lessened stocks of lean cattle and mountain sheep.

	Population	Cattle	Sheep	Pigs
Gt. Britain	23,202,281	4,785,846	22,048,281	2,477,619
Russia . .	74,139,394	25,444,000	45,130,800	10,097,000
Denmark .	1,662,734	1,118,774	1,751,950	300,928
Prussia .	18,491,221	5,634,500	17,428,017	2,709,709
Saxony .	2,225,240	638,460	371,989	270,462
Wurtemburg	1,720,708	957,172	683,842	216,965
Holland .	3,618,459	1,333,887	930,136	294,636
Belgium .	4,529,461	1,257,649	583,485	458,418
France .	37,386,313	14,197,360	33,281,592	5,246,403
Spain . .	15,658,531	2,904,598	22,054,967	4,264,817
Austria .	36,267,648	14,257,116	16,964,236	8,151,608
Bavaria .	4,807,440	3,185,882	2,058,638	926,522
U. States .	31,445,080	16,911,475	23,317,756	32,5[illegible]5,267

Stock. In Finance and Political Economy, a term employed to denote capital which has been expended by the owner, in the course of his business, or subscribed to a joint fund, to be managed by directors, or lent to the government on behalf of the nation, with the view either of carrying out public works, or of serving as a fund for carrying on warlike operations.

The first of these sources will be familiar to the readers of Adam Smith, with whom *stock* is frequently employed as a synonym for *capital*. This usage is, however, nearly obsolete at present. The second and third are more familiar, and are related. In the beginning of those commercial adventures which were created by charters and secured by a monopoly, the parties subscribing were held to possess stock in proportion to the amount to which they pledged their names or credit, and the earliest stocks were those of the East India Company, the African and Russia Companies, and the Bank of England. In most of these cases, the company was said to be regulated.

When public debts were created, or (to be more correct) when such debts were secured by parliamentary pledges, and were therefore guaranteed, the sum subscribed was, in imitation of those older arrangements, called a *stock*, particular sources of public income being pledged for the payment of the interest, and in many cases for the repayment of the principal. In course of time [National Debt], these separate funds were formed into one, called *consolidated stock*, a term which has been gradually abbreviated into *consols*.

In later times, the word *stock* has been used specifically to designate any subscribed capital which is divisible into optional parcels, and which is therefore contrasted with *shares*. When a trading company, as, for instance, a bank, railway, or any similar public undertaking, is constructed, it is, or has been, customary to raise the necessary capital by the issue of shares of greater or less amounts. These shares, as long as they are called by this name, are, as a rule, indivisible. When, however, as in many cases, it is more convenient to allow purchasers to choose their own quantity, the shares are converted into stock. As a rule, capital held as stock passes more freely from hand to hand, and is therefore more marketable; but it is, on the other hand, more liable to fluctuations in value.

Stock Dove (stock, in the sense of a tree-stem). The name of the wild species called *Columba Œnas* by Linnæus. It frequently breeds in leafy pollards, called *stocks*.

Stock Exchange. The mart in which public and private securities are negotiated and bargained for. The word generally used in foreign countries as an equivalent is *bourse*. Since the Revolution, and the parliamentary guarantee of public debts, dealings in the stocks, which compose the corpus of such debts, either on the dealer's behalf, as speculator, or for some other person as broker, are obvious and inevitable; and as the disposition to speculate or risk, or, as some may be pleased to say, gamble, is almost innate in men, it is not remarkable that from the earliest days in which stocks were regularly saleable, there should have arisen a class of men who made it their business to watch the turns of the market and the feelings of the public, with a view to making a profit out of transactions which do not represent real sales or purchases, but only the risks of the market, or, as they are technically called, *time bargains*. This traffic in course of time was extended to other stocks than the public funds; and jobbers, as they were called with some tinge of disapprobation, made every conceivable article of value, and very often every conceivable contingency, a subject for such transactions. Thus, for instance, we are told that the life of the first Napoleon was perpetually speculated on, and that the insurance on his life for the single year 1804 was often more than fifty per cent.

At first these stock exchange speculations were held in the Royal Exchange; but in 1698 the jobbers removed to Change Alley, at that time a large open space, and carried on their speculations without discrimination of persons, on the principle, in short, of a public betting ring, or of such gatherings of gamblers as used till lately to congregate in St. Bride's Passage, and afterwards on the vacant space near Farringdon Street. In a short time, the superior members of the fraternity took up their quarters in Jonathan's coffee-house. Afterwards there was a new Jonathan's as well as an old; and these places were the home of the stock jobber for a century.

After the brokers had quitted the Royal Exchange, the corporation of the city strove to recall them, and in order to secure their return inscribed a clause in the broker's bond—brokers, in pursuance of an Act of William III., being licensed and regulated by the corporation—to the effect that they should carry on their business in the Royal Exchange. This clause, though long continued, was never operative.

The occupation of a jobber was always looked on with disfavour by the general public and the stricter men of business, and discountenanced, in appearance at least, by the houses of parliament. We say in appearance, for some of the worst cases of dishonesty on the Stock Exchange, as, for instance, that of the South Sea Scheme in 1720, were clearly traceable to members of the legislature. These gentlemen passed Acts perpetually against transactions in which they were deeply concerned, and by which they were in many cases seriously compromised. The Acts of 7 & 10 George II., commonly called Sir John Barnard's Acts, had a different origin. Sir John Barnard hoped to check the practice of time bargains by making such Stock Exchange debts irrecoverable, and for a time the author of the enactment was reputed to have gained his end, and certainly he earned the unmixed hatred of the stock jobbers. But they devised a means of

escape through the machinery of an internal and voluntary police; and within a very short time after their passing, these Acts became wholly inoperative, and in all probability Stock Exchange bargains were met more punctually and regularly than any other liabilities. Sir John Barnard's Act, long obsolete, was repealed a few years ago.

Stock Exchange transactions were treated rigorously as debts of honour; and defaulters, called in the grotesque language of the Exchange *lame ducks,* were peremptorily excluded from the alley. In 1787, in consequence, it seems, of some extraordinary irregularities, it became the custom to exhibit the names of defaulters on a black board. The members of the fraternity were too cautious to expose themselves to the risks of libel, in case some expelled member, on whom this curious sentence was inflicted, thought proper to seek a remedy in a court of law. Nothing, we are informed, could be more innocuous than the outer shape of a fiat of expulsion from the privileges of a broker or jobber. It was simply couched in these words: 'Any member with whom A B (the defaulter) does business is requested to communicate with C D.' The police of the Stock Exchange is vested in a committee of twenty-eight, whose power is absolute, and whose sentence is final, and no person can be deprived of his privilege by a less number than twelve members of the committee. In the new Stock Exchange, the first stone of which was laid in 1801, the members are elected by ballot, and pay an annual subscription of ten guineas. They are also required to find security to a certain amount for some years, and the most energetic measures are taken against any stranger who even inadvertently enters the precinct.

All important stocks are quoted on the Exchange, and the rates at which they are bought and sold are given in the daily papers. It is understood that the quotation of a stock on the Exchange is a considerable advantage to it, and the brokers have exercised a wholesome discipline not only over defaulting jobbers, but over dishonest governments, by excluding their securities from the public market. The most absolute monarch is, in these days of public debts, kept in awe by the committee of the Stock Exchange, for a sentence of exclusion from its bargains is almost fatal to any future financial projects. In ordinary commercial stocks, especially in joint-stock companies for trading purposes, the privilege of quotation on the Exchange is frequently bargained for at a considerable sum with leading brokers, partly that the stock may secure the advantage of an open market, partly that it may be placed, or taken up by buyers of shares.

As the committee of the Stock Exchange attempt to regulate by an internal police the commercial good faith of the brokers, so they are bound, as the society virtually possesses a monopoly of the trade in securities, to check unfair practices against the public. On this point, however, they are less sensitive; and it may be doubted whether the real influence of the Stock Exchange, and the importance attached by the promoters of joint-stock companies to Stock Exchange quotations, have not suffered a severe shock by the intrigues of a few members of that body against joint-stock banks. During the present year (1866) it is plain that attempts have been made on the part of some persons connected with the Exchange to depreciate existing shares, and this has been carried to such an extent as to destroy property in some cases, and considerably depress its value in others. Of course such attempts spring from the practice of making time bargains, a practice coeval with a stock exchange, and inseparably connected with it; but if the custom at a particular crisis becomes a conspiracy, and a serious public evil, the remedy should be provided at the hands of those who are interested in the reputation, and so in the public usefulness, of the Exchange.

On the whole, negotiations on the Stock Exchange, even when of a purely speculative character, subserve (like the trade of a corn dealer) a considerable public benefit. The eagerness with which a corn dealer watches the market for a rise or fall tends to equalise prices, and, more important still, to economise resources in times of dearth and plenty. Similarly, the speculations of the stock and share broker obviate excessive fluctuations in the price of securities. Were it not for these agencies, a slight distrust felt about any stock might induce a panic among the general public, or irrational confidence an undue exaltation in its market value. The stock broker, buying when the former case is likely to occur on insufficient grounds, arrests the fall, and by selling when the latter motive is operative, checks the rise. There can be no doubt, that with so vast an amount of subscribed capital in the market, amounting certainly to not less than 2,000 millions, the variations in the value of these stocks would be infinitely greater, and the effects of confidence and panic incomparably more disastrous, if it were not for the jobbers and speculators on the Stock Exchange.

The language of the Stock Exchange is eminently metaphorical. The explanation of some of these terms has been given by Mr. Francis, whose *Chronicles and Anecdotes of the Stock Exchange* is a very amusing and instructive work. The writer of this article has been indebted to it for some of the historical facts quoted above.

Bull: a person who buys stock on account, not intending to hold it, but simply, at a date agreed on between the dealers, to pay or receive the difference between the price at which he values it, and that at which it actually stands on the day specified.

Bear: a person who sells stock on account on the same terms, and with the same purpose.

Lame Duck: a defaulter at the settlement of such bargains, whose name is exposed on the pillory of the Stock Exchange, the dreaded black board.

Backardation: a consideration given to keep back the delivery of stock, when the price is lower for time than for money.

Continuation or *contango* is the premium given when the price of funds in which a person has a jobbing account open, is higher for time than for money, and the settling day is arrived, so that the stock must be taken at a disadvantage. In this case a per-centage is paid to put off the settlement and continue the account open.

Jobber: a term applied to those who accommodate buyers and sellers of stock with any desired quantity.

For information as to the commercial history of many eminent members of the Stock Exchange, see the work above referred to.

Stocks. A well-known kind of punishment. The practice of confining men by the legs was so common as to have given the ordinary name to a chain of any kind in several languages: e.g. Gr. πέδη, Lat. compes, Eng. fetter; all from πούς, pes, *foot*. The stocks in England have been, generally speaking, used rather for restraint than punishment, constables being empowered to put disorderly persons into them; but this penalty was likewise ordered by some statutes as a punishment on conviction. It is now disused.

Stocks and Dies. The iron handle which receives the *die* that cuts the path or the thread of a screw, is known by the name of a *stock*. It is generally made so as to accommodate a great variety of the dies employed in such cases.

Stockade (Fr. estocade, Ital. stoccato). In Civil Engineering, stockades are sometimes used in defences of the seashore against the sea, or for the banks of rivers exposed to the erosion of the current; but the best protection against the current is brushwood with the branches pointing upwards against the stream.

STOCKADE. In Fortification, a strong timber wall, eight or nine feet high, loopholed for musketry fire, and sometimes having a ditch in front, and banquette in rear.

Stocking. A garment for the foot and leg. Stockings were at first made of cloth or of milled strips sewn together. Silk-knit stockings seem to have been introduced from Spain in the sixteenth century. Knit stockings are wrought with needles made of polished iron or brass wire, which interweave the threads and form the meshes of which the stocking consists. Woven stockings are manufactured on a frame of polished iron, which was invented towards the close of the sixteenth century.

Stoics. A celebrated sect of antiquity; so called from the *stoa* or *porch* in Athens, which was the scene of the discourses of their founder Zeno (B.C. 300). The Stoics are proverbially known for the sternness and austerity of their ethical doctrines, and for the influence which their tenets exercised over some of the noblest spirits of antiquity. To give a connected and systematic account of the philosophical principles on which they grounded their moral precepts is a less easy task than, from the notoriety of the latter in some of their main features, might have been anticipated. Their speculations were not confined to ethical subjects, but aimed at embracing the whole circle of human knowledge; physics, theology, and logic, no less than morals and politics. Their system, as far as we can gather from the notices preserved by Cicero, Diogenes, and others, appears to be an attempt to reconcile a theological pantheism and a materialist psychology with a logic which seeks the foundations of knowledge in sensible experience, and a morality which claims as its first principle the absolute freedom of the human will. Of the mode in which they combined dogmas apparently so inconsistent into a philosophical whole, we have accounts sufficient to inspire us with respect for the earnestness and strength of character possessed by the leaders of their sect, and with admiration of their subtlety, ingenuity, and depth. We discern, at the same time, in all their speculations, equally a narrow and controversial spirit, very unlike the critical but comprehensive impartiality which marks the philosophical writings of their great predecessors—of Plato, and, in a still more eminent degree, of Aristotle. The philosophy of the Stoics was essentially polemical. On every side it presented an armed front to an opponent. It sought to confute the academic scepticism by the strenuous assertion of the truth of sensible perceptions, and the validity of the judgments to which they lead by a vigorous protest in favour of the common sense of mankind as opposed to the theories of the schools. Sensation, they affirmed, is not merely a passive affection of the mind; it becomes, under certain conditions, perception or *comprehension* (κατάληψις), a faculty whereby the mind reaches beyond itself, and *lays hold*, as it were, on outward being. From the acquisitions of sensible experience are formed conceptions and judgments of successive stages of generality, which it is the province of the reason to construct into philosophical system. Such is the stoical logic, which is consequently a *material*, and not, as with Aristotle, a *formal* science. An equally controversial bearing is perceptible in the remainder of their philosophy. Their greatest enemies, the Epicureans, had adopted the *mechanico-corpuscular* theory of Democritus, which accounted for all physical phenomena by the varieties in size and figure of the ultimate atoms of which all substances are the aggregate. The fortuitous concretions which thus became the first cause of all things, had attracted the partialities and won the assent of a sect averse in all things equally to limitation or constraint. The Stoics espoused the opposite doctrine of a one all-pervading substance, a permeating ether, a creative fire, the source of life and law to the material

universe. On this they built their doctrine of a universal providence, excluding chance in the least things as in the greatest, and directing all events by irresistible necessity to the promotion of perfect good. The same hypothesis furnished them with a ground for the first principle of their ethical doctrines. 'Live according to nature' is, with the Stoics, the expression of the coincidence which ought to exist between the human will and the universal reason, which, as we have seen, they identified with the life and power of nature. This coincidence is virtue, the only good; as vice, its opposite, is the only evil. All things else are in themselves indifferent; being approved or disapproved only by comparison. Virtue is the perfect harmony of the soul with itself; vice is, in its essence, inconsistent and self-contradictory. The wise man, the ideal of human perfection, is absolutely, and without qualification, free. His actions are determined by his free will with a power as irresistible as that by which universal nature is guided and animated. In the one no less than in the other, freedom and necessity are one.

In these doctrines the controversial character to which we have adverted is sufficiently obvious. Much, however, that is exaggerated and paradoxical, both in the tenets of the Stoics and in those of their opponent Epicurus, is to be accounted for by a reference to the political circumstances of the age in which both lived.

In the declining period of the Roman republic, as well as in the darkest periods of the empire, we find the noblest Romans seeking for consolation in the doctrines of one or the other of these rival sects. Brutus, Seneca, Epictetus, and the philosophic emperor Aurelius, are among the names of the most celebrated Roman Stoics. Little, however, was done by the Romans to advance the speculative part of the stoical philosophy, which was indebted for its systematic form to Cleanthes and Chrysippus.

The chief sources of information concerning the doctrine of the earlier Stoics are the philosophical works of Cicero; for their logic, the *Academic Questions*; for their ethics, the treatise *De Finibus*, and the *Tusculan Questions*; and for their theology and physics, the books *De Natura Deorum* and *De Fato*. See also *Diog. Laert.* 1. vii. Plutarch, *Adv. Stoicos*, &c.; Ritter, *Hist. of Ancient Philos.* xi. part v.

Stoker. The labourer employed to replenish a furnace with coals.

Stoking. The operation of replenishing a furnace with coal, and of keeping it in proper order, by clearing away the ashes and clinkers, so as to maintain a vigorous combustion. Much skill is needed to stoke the furnace of a steam boiler successfully; and one stoker will often be able to keep the steam well up when another of equal strength and diligence will fail altogether. One main indication to be fulfilled is to spread the coal evenly over the bars of the grate, and to leave no holes or open places in the fire, through which the cold air will rush, and diminish the temperature of the furnace. In long furnaces, it is necessary to be careful to throw the coals well back against the bridge, so as to keep that part of the grate covered; and it will often be found that more steam will be generated if the furnace bars are shortened should their length exceed six feet. The large lumps of coal should be broken up with a hammer into pieces of the size of a hen's egg. In locomotives the coal should be fed a little at a time, and it will often be advisable to shut off the feed water temporarily in ascending inclines.

Stola (Lat.; Gr. στολή). A dress of which the name was borrowed by the Romans from Greece, but acquired in their language a peculiar signification; being the habit appropriated to women. It was a long vest, coming down to the ankles; was worn within doors, and covered by the palla or cloak when they went out; as described by Horace, *Sat.* I. ii. 99:—

Ad talos stola demissa et circumdata pallâ.

Common prostitutes, at least in the age of Horace, were not permitted to wear this distinguishing garb of the Roman lady.

The stole, as an ecclesiastical ornament, is a long narrow band, or scarf, with fringed ends, worn in the Roman and other churches by deacons over the left shoulder, and by priests crossed over the breast to the girdle, and thence descending in front on both sides down to the knees. [VESTMENTS.]

Stole, Groom of the. An officer of the royal household in the lord chamberlain's department. He is first lord of the bedchamber; his title is derived from the long robe (stola) worn by the sovereign on solemn occasions.

Stolon (Lat. stolo, *a shoot*). In Botany and Horticulture, a sucker or young shoot produced from the root or crown, which takes fresh root at intervals, and thus forms independent plants.

Stolzite. A name given to Tungstate of lead, after Dr. Stolz. [SCHEELETINE.]

Stomacace (Gr. στομακάκη). A fetor of breath, arising from ulcerated gums. Mouthwashes, with tincture of myrrh and borax, and the internal use of tonics, are the remedies which relieve it.

Stomach (Gr. στόμαχος, strictly *a mouth*, hence *the throat*: in later Greek medical writers, the word is used in the modern sense of the term). The human stomach is a somewhat oblong and rounded membranous bag, situated in the epigastric region. It is largest on the left side (or *cardiac* end), and gradually diminishes towards the right or lower orifice, which is called the *pylorus*. Like the intestines, the stomach has three coats or membranes, connected together by cellular membrane. The exterior or peritonæal coat is a dense firm membrane; the internal or villous coat is

soft, mucous, and vascular; the central coat is muscular, and the glands of the stomach are situated between it and the villous coat. The stomach is largely supplied with nerves, which come from the eighth pair and sympathetic. They are derived chiefly from the cœliac or solar plexus, and are accompanied by veins which empty themselves into the vena portæ. The lymphatics of the stomach proceed directly to the thoracic duct. [ANATOMY; DIGESTION.]

Stomach Pump. A small pump or syringe with two apertures, the valves of which are so arranged as to admit of liquids being drawn out of or injected into the stomach, by means of a flexible tube.

Stomapods (Gr. *στόμα, a mouth*, and *πούς, a foot*). The name of an order of the *Crustacea*, comprehending those in which the maxillary feet are formed like the first four thoracic feet.

Stomata (Gr.). In Botany, the term applied to certain passages through the epidermis of plants, having the appearance of areolæ, in the centre of each of which is a slit that opens or closes, according to circumstances, and lies over a cavity in the subjacent tissue. They are universally regarded as spiracles or breathing pores.

Stone, Artificial. Many kinds of material have been employed in the manufacture of artificial stone. The kinds most in use are some modification of *Roman cement*, hardening rapidly and in damp air; *Portland cement* is still better, but of the same nature; *terra cotta*, a kind of brick that requires burning; and *silicious stone*, a composition consisting of sand and other material made into a paste by an aqueous solution of silicate of soda, the water being driven off in a kiln and the material cemented by a kind of glass.

A new material, called *concrete stone*, has recently been introduced, which seems likely to supersede all these for many purposes. Any stony materials, however incongruous, are made into a paste with fluid silicate of soda, and then by mere exposure to a solution of chloride of calcium, double decomposition is induced, the silicic acid combining with the calcium to form silicate of lime, a cementing medium firmly attaching all the particles, and the chlorine combining with the soda to make common salt, which is readily washed away.

The great objection to most of the older varieties of artificial stone having a clay basis is that they will not long endure the action of weather, are apt to crack, and also to become covered with green vegetation. Stones also that pass through the kiln almost invariably lose their proportions and become distorted; this, however, is more especially the case with the clays, and the concrete stone is free from it.

Stone in the Bladder. [CALCULUS; URINE.]

Stone Blue. A compound, the basis of which is usually an impure starch, or mixture of starch and gluten, being the starchmakers' refuse, coloured either by indigo or Prussian blue. It is used in the laundry to cover the yellow tint of linen.

Stone Borers, called also **Lithophagi.** Molluscous Bivalves, which, by means of a fleshy foot, on which they turn as on a pivot, perforate or bore into rocks.

Stone Coal. A common name for ANTHRACITE.

Stone Curlew. The name of a large species of plover, the *Œdicnemus crepitans* of Temminck. It appears in England at the latter end of April; frequents open hilly situations; makes no nest, but lays two eggs on the bare ground; and emigrates in small flocks about the end of September.

Stone Galls. A technical term applied to nodules of clay occurring in sandstone; they often fall out on exposure to weather, and render the stone unfit for architectural purposes.

Stone, Natural. Stones are of many kinds and used for many purposes. They are chiefly referable to the following varieties: LIMESTONE, SANDSTONE, MARBLE, and GRANITE. Fissile stones are called SLATES, SLABS, or FLAGS. Building stones, capable of being worked readily by the tool, are called *free stones*. Stones used for road-making are called ROAD METAL.

The selection of a stone for any required purpose is a matter involving much knowledge and experience. Reference should be had to the nature of the exposure, the part of a building, whether foundation or superstructure, and the style of the building, as stones that will stand one kind of exposure fail in another place, and those that are sound when placed square, so as to expose only a vertical section, will not always last if much sculptured. It is well known that many stones, perfectly durable in the neighbourhood where they are found, may not last if removed to buildings in large towns at a distance.

Stones are subject to injury when placed in buildings, in various ways. 1. Being removed from the quarry, where they contain much water, they are exposed to irregular drying, and consequent cracking and peeling. Hence the importance of attending to the planes of stratification. 2. When absorbent, as they are very unequally exposed to the rain in the different parts of a building, they must be selected with this end in view. 3. They are exposed to the acid vapours present in the air. Should the stone not be placed in the building in its natural position, it will be more subject to peeling than if so placed. Should it be absorbent and not previously weathered, it will be very apt to rot; and under any circumstances, if a limestone or with a calcareous cement, it will be chemically acted on. [BUILDING MATERIALS.]

Stone Ochre. A yellow pigment resembling Roman and Oxford ochre. Stone ochres are found in balls and globular masses of various sizes in solid stone, or lying near the

surface of rocks, in the Carboniferous Limestone quarries of Gloucestershire and elsewhere. [LIMONITE.]

Stone, Preservation of. The subject of the preservation of stone has long attracted attention, but as yet with no thoroughly satisfactory results. The most usual application consists of some variety of paint, but this requires repeating from time to time. The method most likely to be effectual is some modification of a process introduced some years ago, first in Germany, and then in England. This method involves the deposit on the surface, and within the substance of porous stones, of a thin glaze, indestructible, and penetrating more or less according to the degree of porosity.

It is a remarkable but well-ascertained fact, that the same preparation which appears satisfactory, even on a large scale, on some kinds of stone in certain localities, cannot be depended on either for the same stone in other localities, or for other stones in the same exposure. Thus, no one treatment has been found to succeed generally. It is also very difficult, if not impossible, to decide beforehand with any certainty which of a number of stones will be likely to resist exposure, and which will decay, under given circumstances. This, however, is easier than to restore stones, or to stop the decay when they have become seriously injured by exposure.

Almost all stones will resist exposure better if hardened and weathered for some time before being used. If, also, they can be preserved till lichens grow upon them, they are still more likely to resist the action of acid vapours. Stones that have once thoroughly decayed from the surface hardly admit of any treatment.

Stone Salt. [ROCK SALT.]

Stonechat. A species of warbler, forming the type of the genus *Saxicola* of Bechstein, so called because its chatter was supposed to resemble the knocking of stones together. It is the *Sylvia rubicola* of Latham; *Motacilla rubicola* of Linnæus. Also called the *chick stone*.

Stonecrop. The common name for *Sedum acre*, and also used as a popular name for the genus *Sedum*.

Stonesfield Slate. Two beds of calcareous flagstone or tile, sufficiently fissile to be available for roofing purposes, are worked under this name near the village of Stonesfield in Oxfordshire. They are represented by somewhat similar beds at Colley Weston, near Stamford in Northamptonshire, and they occupy a definite geological position at the bottom of the upper division of the lower oolites, between the Great Oolite and Fuller's earth. They are chiefly interesting as containing the most distinct remains of mammalian quadrupeds that have yet been found in beds older than the Tertiaries. These animals are small. The lower jaws of several individuals have been found, and they are referable to different genera, some marsupial. Many other remarkable fossils have been found, proving the near vicinity of land at this period in England.

Stooking. The Scotch term for setting up sheaves of corn in stooks, i.e. shocks. The operation is performed soon after the corn is cut; it being previously tied into bunches or sheaves.

Stool (A.-Sax. stol, Ger. stuhl). In Horticulture and Arboriculture, a stemless mother-plant used for propagation by annually bending its branches into the soil; the branches so bent down forming layers, and the process being designated *laying* or *layering*. Also the root or stump of a timber tree, which throws up shoots. Coppice wood consists chiefly of the shoots sent up by the roots or stools of trees or shrubs which have been cut over by the surface. In general, all Dicotyledonous trees are endowed by nature with the property of sending up shoots from the stumps or stools; but this is not in general the case with the Gymnosperms or Coniferous trees, and hence a wood of pines or firs, when once cut down, can never be renewed, except by seeds.

Stools. Small channels outside a ship to receive the dead-eyes of the backstays.

Stop Order. In Law, an order which may be obtained by any person interested in a fund in the Court of Chancery, for the purpose of preventing the fund from being transferred or paid out without his knowledge.

Stop Valves. Valves introduced between boilers where several are employed to drive an engine, to the end that any boiler may, when desired, be thrown out of use without impairing the efficiency of the rest, which is done by shutting the stop valve in the steam pipe which connects it with the other boilers of the system.

Stoppage in Transitu. In Mercantile Law, the right which an unpaid vendor of goods has, in the event of the insolvency of the purchaser, to stop the goods while they are on their way to the consignee, and before the termination of their journey.

Stopper. On Shipboard, an apparatus for applying the brake to the capstan when the cable is running out. *Stoppers* are also obstacles placed firmly at a given point in the cable to prevent it from running beyond that point through the hawse-hole.

Stoppering a Fall. Making fast the fall of a tackle to some fixed object, at a point intermediate between the running and standing ends. [TACKLE.]

Stopping-up Pieces. Timbers used to afford lateral support in launching a vessel.

Storax (Lat.; Gr. στύραξ). A fragrant balsamic exudation from the *Liquidambar styraciflua* It is generally much adulterated.

Stork (A.-Sax. storc). An English name, equivalent to the *Ciconia* of modern ornithologists. The white stork (*Ciconia alba*) visits England, though rarely.

Storm (Ger. sturm; connected with the verb *stir*). The causes of those violent commotions of the atmosphere to which we give the names of *storms, tempests, hurricanes, tornadoes*, &c. are involved in great obscurity, chiefly from the difficulty of obtaining a pre-

cise knowledge of the various circumstances with which they are accompanied. In order to ascertain the general laws of these phenomena, it would be necessary to determine, in a great number of particular instances, the place and time at which the storm begins and ends, the path described by it, the extent of atmosphere disturbed, the direction and force of the wind, and the barometric pressure at every part of the disturbed column during the whole time of its continuance. But several of these points could be determined only from the comparison of a great number of simultaneous observations on that tract of the earth's surface over which the storm passes; while, from the nature of the thing to be observed, it is evident that a few insulated observations can at best be expected in almost any case. Besides, a storm for the most part passes over some part of the sea, where, unless a ship unfortunately happens to be caught in it, no observation can be made, and no evidence can be obtained of its existence.

It is in the torrid zone that storms display the greatest violence, and rage with most destructive fury. In more northern latitudes they are comparatively rare, and in the polar regions they seldom amount to more than a strong wind. These facts seem to show that there is some connection between violent atmospheric movements and the velocity of the earth's surface, due to axial rotation in different latitudes.

Until recently, it was generally believed that during a hurricane the wind at every part of the agitated mass blows in a rectilinear and parallel direction, and a storm was considered to be sufficiently explained when it was described as a wind blowing with a velocity of 100 or 120 miles in an hour. A comparison of the recorded accounts of the circumstances attending several storms has of late years shown that this idea was erroneous, and that the phenomena are considerably more complicated.

Franklin appears to have been the first who remarked that storms travel in a direction opposite to the actual movement of the wind at the time when the storm is raging; and he ascribed the phenomenon to a great but partial rarefaction of the air, arising from the sudden precipitation of vapours, or other causes, the consequence of which would necessarily be a simultaneous rush from all quarters to fill up the vacuity; and the mass of air being thus set in motion by a sort of aspiration, the gale will be first felt at those places towards which it blows. (*Letters and Papers on Philosophical Subjects.*) In a work on winds and monsoons, published in 1801, Colonel Capper was led, from a comparison of the details respecting the hurricanes at Pondicherry and Madras in 1760 and 1773, to remark that these hurricanes must have been whirlwinds, whose diameter could not exceed 120 miles, and that the velocity of the wind at any point was due to the rotatory velocity of the vortex. He also supposed that, besides the gyratory movement which forms the characteristic of the whirlwind, a storm has probably also progressive motion. Colonel Capper's speculations, however, appear to have met with little attention until the subject was taken up by Mr. Redfield, of New York, who, in a series of papers published in the American journals, diligently collected and examined a great number of observations relative to the storms of the West Indies and North American coasts, and arrived at similar conclusions. The following general phenomena appear to be established: 1. The severest hurricanes originate in tropical latitudes to the north or east of the West Indian Islands. 2. They cover simultaneously an extent of surface from 100 to 150 miles in diameter, acting with diminished violence towards the exterior, and increased energy towards the interior of that space. 3. The tract over which the hurricane passes is not a straight line. South of the parallel of 30° north latitude, it proceeds in a westerly course inclined to the north; but when it comes to about this parallel, it changes rather abruptly to the north and east, and continues to incline gradually more to the east. The average progressive velocity appears to be from fifteen to twenty-five miles per hour. 4. The duration of a storm at any particular place depends, of course, on the extent of the mass of agitated air, and the progressive velocity; and storms of smaller extent move with even greater rapidity than large ones. 5. The direction of the wind in a hurricane is not in the direction of its progress. When the progressive motion of the storm is westward, the wind at the commencement is from a northern quarter, and during the latter part of the gale from a southern quarter of the horizon. When the progressive motion is eastward, the phenomena are reversed; the wind blows at first from a southern quarter, and towards the end of the gale from a northern quarter of the horizon.

From these phenomena, and particularly from the last, Mr. Redfield concludes that the great body of the storm whirls in a horizontal circuit round a vertical or somewhat inclined axis of rotation, which is carried forward with the storm; and that to a spectator placed at the centre the direction of the rotation is invariably from *right to left*. It is to be understood, however, that the phenomena now described, and the conclusions drawn from them, apply only to the northern hemisphere.

Another fact deserving of attention is, that the barometer, in all latitudes, sinks during the first half of the storm in every part of its track, and rises during the second. This phenomenon is ascribed to the effects of the centrifugal force of rotation; and such is the regularity of its occurrence, that it has been considered as affording of itself a strong proof of the rotatory character of the motion.

Colonel Reid, of the engineers, having been officially employed to restore the government

buildings at Barbadoes, blown down by the great hurricane of 1831, was led to investigate the subject generally; and in his work, entitled *An Attempt to Develope the Laws of Storms, &c.*, he has collected and given the results of an immense number of details, obtained from an examination of ships' logs furnished to him by the Admiralty, and from other sources. These results he considers as confirming in all respects the conclusions of Mr. Redfield respecting the gyratory motion of the gale from right to left; its progressive motion in a curve line, first westward, and then towards the north and east; the position of the vertex of the curve at or near the 30th degree of latitude; and the fall of the barometer during the first half of the storm, and its rise during the second. Colonel Reid has also given an account of several great hurricanes in the southern hemisphere, from which it appears that the southern storms follow exactly the same laws as the northern, but in a reversed order. The direction of the rotation is from *left to right*; the centre of the gyrating mass advances first eastwards, then turns towards the south, and falls off towards the south-west and west, the vertex of the curve being at the 30th degree of south latitude. In the northern hemisphere, the West Indies and Atlantic coast of North America appear to be the places where storms most frequently rage; in the southern, the focus of storms appears to be placed near the Mauritius.

The uniformity of the direction of the rotatory motion of the hurricane, and its opposite direction in the opposite hemispheres, was explained by Mr. Redfield from theoretical considerations respecting the origin of storms, which he supposes to be produced by the mingling and collision of two atmospherical currents near the outer border of the trade winds; namely, the superior or equatorial stream, and the polar stream, which constitutes the *trades*. On looking at the curves representing the paths of the hurricanes on the charts projected by Mr. Redfield and Colonel Reid, it is difficult to avoid the conclusion that the direction of their progressive motion is mainly determined by the configuration of the continent. Whilst hurricanes are gyrating masses of air with a vertical axis, *squalls* appear to be caused by similar gyratory movements, in which, however, the axis is horizontal.

Although the subject of storms has received much elucidation from the labours of Dove and others, aided by the resources of the electric telegraph, still much further investigation will be required before the phenomenon is fully understood. Independently of the interest which attaches to the subject in a meteorological point of view, a knowledge of the general laws which regulate the phenomena of storms would be of immense importance, inasmuch as it would enable the navigator to avoid those tracts of the ocean in which they prevail at particular seasons, or at least, if surprised by a storm, to steer on the course by which he may soonest escape from it or fall into its wake. Even the knowledge at present possessed, imperfect as it is, has been employed by the late Admiral Fitzroy with a certain amount of success in the prediction of most of the storms which have recently visited these islands; and the exhibition of his storm signals at our principal ports has been the means of preserving many lives and much property. (See, in addition to the works already cited, *Silliman's Journal* from 1831; Prof. Forbes' 'Reports on Meteorology,' in the *Reports of the British Association* for 1832 and 1840; and the *Edinburgh Review*, vol. lxviii.) [Winds.]

Storms, Law of. [Storm; Winds.]

Storthing. The parliament of Norway. It is elected once in three years, and sits every year for the despatch of business. The election is double. Every qualified person (an owner or life-renter of land paying taxes in the country, and everyone possessing land or houses of 150 rix dollars value in towns) has a vote for the election of councillors, who elect out of their own body the representatives of the country. These must be from 75 to 100 in number. The storthing, when elected, divides itself into two houses; one-fourth, chosen by the rest, joining the *lagthing*, or upper house, which also forms a court before which the ministers may be impeached; the remainder the *odelsthing*, or lower house. The storthing has the usual powers of a legislative assembly in a constitutional country, and the king has only a suspensive veto; which, if the storthing passes a law three times in six successive years, becomes of no effect. This was exemplified by the law for the abolition of hereditary nobility, passed in 1821.

Stove (Ger. stube, *a room* or *chamber*: in old Saxon stov, stowa, is any dwelling or enclosed place; the Frisian stev, the Icelandic sto, and the Swedish stö, have the same meaning). A receptacle for the combustion of fuel for the purpose of heating houses, &c. The common fire-grate for the combustion of coal, with its various appendages, is generally called a *stove*; hence *register stoves, Bath stoves*, &c. These are often, and indeed generally, very unscientifically constructed, and calculated to consume a large quantity of fuel, with a proportionate waste of heat. They are generally intended to diffuse warmth principally or entirely by *radiation*, and should be placed as near the ground as possible; while the different parts into the contact of which the burning fuel is brought should be of fire-brick, or some similar composition, which is a bad conductor but a good radiator of heat. It is manifest that in our common fire-places the enormous volume of hot air which passes up the chimney is not available as a source of heat; hence, in colder climates, and where greater economy of fuel is studied, the fireplace is frequently closed in, and contained in an iron box which projects into the room, while the heated air before it

finally enters the chimney is made to circulate through tubes or pipes, to which it communicates much of its excess of heat, and these again impart it to the surrounding air. What are termed *German stoves* are usually made upon such principles; and in them the fuel is often introduced, and the air required for the support of its combustion admitted, on the outside of the room in which the stove with its flues and heating surfaces is placed.

In *Arnott's stoves* the heat is similarly but more scientifically economised. Only enough air is admitted to keep up the slow combustion of the fuel, and the heat is communicated to the radiating surfaces of the stove; so that before the air which has passed through the fuel finally enters the chimney it has been deprived of the greater part of its available heat. These stoves are also so constructed as, by means of thermometric or self-acting registers, to adjust with much nicety the supply of air, so that neither more nor less may enter than is required to maintain the combustion of a given quantity of fuel.

In *Fcetham's air-stoves* the common open fire is retained; but the heat is to a certain extent economised by causing the hot air before it enters the chimney to communicate a portion of its heat to an iron box, over which a current of air passes and is sent warm into the room.

It is manifest that our common open fires must act as powerful ventilators, and that the large quantity of air which is driven up the chimney must be supplied in some way or other through the apartment in which the fire is burning. This supply of air is generally left to chance, and finds its way into the room by crevices in the doorways and window sashes, or between the boards of the floor, or any similar accidental passage through which it can make its way; and as, in London at least, the air always abounds in fuliginous particles, these are carried in along with it, and show its track by the blacks which it deposits. If this supply of air is inadequate, and it generally is so in new and well-built houses, in consequence of the tightness of the doors, windows, and floors, the chimney of necessity smokes, and the door or window requires to be left open to prevent such an effect. This evil may usually be effectually prevented by admitting fresh air from without through some proper and adequate channel, and various ornamental or concealed apertures may be contrived for the purpose; in the best arrangement of which, however, much practical as well as theoretical skill is often essential.

When rooms are warmed by German or Arnott's stoves, the ventilating powers of which are very inferior to the open grate, *ventilation* requires to be strictly attended to. Where buildings are warmed by currents of hot air sent up from stoves on the basement story, great attention should also be paid to ventilation; and in such cases the leading object should be to send in a large volume of air very moderately heated (to about 100°), rather than a small quantity of very hot air: the latter does not readily mix with the surrounding cold air, but forms a distinct and rapidly ascending column, which does not diffuse itself where most wanted; and it is apt to have a disagreeable and burnt odour, arising from the charring of the particles of organic dust which are carried with the air over the too highly heated surfaces of the stove or flues. A little aqueous vapour, sent in along with the warm air by placing a saucer of water in some convenient situation, is often effectual in preventing the disagreeable sensations occasioned by respiring too dry an atmosphere.

STOVE. In Horticulture, a structure in which tropical plants, requiring a considerably higher temperature than that of the open air in Britain and similar climates, are cultivated. Stoves are adapted for various purposes; but the principal are the *dry stove* and the *damp stove*. The dry stove is a structure the atmosphere of which is heated to the temperature of from 55° to 60° during winter, and in which the plants chiefly cultivated are succulents, such as species of *Cereus*, *Stapelia*, *Euphorbia*, and others having a similar habit. During winter these plants require very little water, and during summer they require intense heat, with abundance of air and water during fine weather. Dry-stove plants are less cultivated than formerly. The damp stove, sometimes also called the *bark stove*, requires a temperature of between 60° and 70° during winter, with a proportionate increase during summer; accompanied, in both seasons, with a high degree of atmospherical moisture. This moisture is produced partly by evaporation from the bark bed in which the plants are plunged, but chiefly by watering the floor of the house, and by syringing the walls and plants. During summer the plants grown in the bark stove require all the light which the atmosphere in this country is capable of producing, though in many cases they require screening from very bright sunshine; they also need a free daily admission of fresh air, as in the dry stove. Both are heated by means of smoke flues, or of hot water or steam, circulated in cast-iron pipes, or in brick or wooden tanks or troughs.

The plants cultivated in the moist stove are exclusively those of the tropics; and those which require the highest degree of heat are chiefly Monocotyledonous plants, such as the ginger, the plantain, the banana, the sugar cane, palms, *Orchidaceæ*, &c.; and such Dicotyledonous plants as the bread fruit, the yam, the mangosteen, and other East Indian plants. The bark bed, or its substitute, the hot-water tank, is employed chiefly for insuring a uniform degree of moisture and heat to the roots, and also as a reservoir of heat to supply the atmosphere of the house in case of any diminution from the flues, water or steam pipes, or the sun. Stoves of every description require a constant degree of attention from the gardener throughout the year, more especially such as are devoted to the palms, the bananas, the pine

apple, the vine, and the *Orchidaceæ*, as well as those employed generally for the forcing of early vegetables and fruits.

Strabismus (Gr. στραβισμός, *a squinting*, from στραβός, *distorted*). An unnatural obliquity in the axis of the eye, arising from various causes. It may often be, to a great extent, overcome, especially in children, by blindfolding the sound eye, presuming one only to be affected. In very bad cases, especially those of squinting inward (and such are by far the most common), an operation which has lately been introduced is often effectual in greatly relieving the deformity; it consists in dividing the internal rectus muscle of the eyeball, which is done by a proper scissors without externally wounding the eyelid.

Straight Arch. In Architecture, the arch over an aperture, whose intrados is straight, but with its joints drawn concentrically, as in a common arch.

Straight Joint Floor. In Architecture. [FLOOR.]

Straining Piece. In Architecture, a piece of timber, designed to prevent the nearer approach of two pieces of timber in a piece of framing. The collar of a queen-post roof may be cited as an illustration of the meaning of a straining piece.

Strains on Guns. [RIFLED GUNS.]

Strait (Fr. étroit, Ital. stretto, Lat. strictus, *drawn together*, *tight*). In Geography, this term signifies a narrow pass or frith separating one country from another.

Strake. In wooden Shipbuilding, the term for a line of planking extending from the stem to the stern. The *garboard strakes* are on the outside, next the keel; the *limber strakes* are within, adjoining the limbers; the *thick strakes* are within also, at different heights between decks; the *sheer strakes* and *black strakes* are on the straight part of the outer sides.

Strakonitzite. A yellowish-green mineral resembling Steatite, found in pseudomorphous crystals at Mutenitz, near Strakonitz, in Bohemia.

Stramony or **Thorn Apple.** The *Datura Stramonium*, an indigenous narcotic plant, the seeds and leaves of which are used in medicine. The dried leaves are occasionally smoked, like tobacco, for the relief of spasmodic asthma; and an extract of the seeds is used as a sedative in some painful chronic affections. [DATURA.]

Stranger (Fr. étranger, from Lat. extraneus, *foreign*). In the Old Testament, the denomination of persons of foreign, i.e. not Israelitish, extraction, resident within the limits of the promised land, and entitled, through conformity to the law, to keep the passover and enjoy the rest of the Sabbath. They were treated with great liberality; but whether allowed to hold land or not, is doubted.

Strangury (Gr. στραγγουρία). A difficulty in voiding urine.

Strap. In a capstan on board ship, an iron bar of great strength forming part of the brake apparatus.

Strata. [STRATUM.]

Strategical Line. In the Art of War, that line which affords better means of communication than all other intermediary lines between two *strategical points*.

Strategical Point. In War, every point on the theatre of war, whatever be its nature, which conduces in any manner to strengthen the line of operation or of communication. *Decisive strategical points* are those only which are decisive in insuring the success of any operations of strategy either for offence or defence. Thus any point may, by the relative situations of the hostile armies, become a decisive strategical point; but the points most likely to do so are strong positions commanding the principal great roads or a permanent bridge over a great river, or blocking up the approach to passes over a range of mountains.

Strategy (Gr. στρατηγία, from στρατός, *an army*, and ἄγω, *I lead*). The science by which a general is enabled to trace the plan of a campaign, determining the positions of which it is necessary to be master, and fixing the direction in which the communications should be established. Strategy has also been defined as the art of placing in a certain position at a certain time a body of troops in fighting order superior to that body which your enemy can then oppose to you. Strategy relates to the movements of an army on the theatre of war, where not in actual contact with an enemy, and merges into *tactics* on the field of battle. [TACTICS; WAR.]

Strath (Gael.; Welsh ystrad). In Scotland, this word is generally understood to signify a valley of considerable size, whose appellation is determined by some river running through it, or some particular characteristic.

Stratification. The arrangement of the various materials of which the earth's crust is composed in *strata*, *beds*, or *layers*, reposing one on another with more or less appearance of regularity, is called, in geological language, *stratification*, and rocks are said to be *stratified* or *unstratified*, to have *conformable* or *unconformable stratification*, accordingly as they present evidences of mechanical or chemical origin, and as they seem to have succeeded each other without or after disturbances altering the horizontality of strata previously placed.

We say, then, that the crust of the earth is *stratified*, when it consists chiefly of distinct strata or layers of different materials. These differ in depth and extent; but (what is most essential to our present purpose) they follow each other, on the large scale and as masses, in an apparently regular and uniform succession in all places, districts, and countries where they admit of examination and have been attentively studied. They appear, in most instances, to rest upon, and are blended with, invaded, and in some few instances overflowed as it were, by substances which are *not* distinctly stratified, and which most geologists have agreed in calling *unstratified rocks*. The former, or the stratified rocks, from their texture and con-

tents have apparently been formed under water; and many of them abound in fossil remains. The *unstratified* rocks, on the other hand, are in some few instances of volcanic origin; but most of them, from their position, texture, and effects upon their neighbours, are METAMORPHIC. *Water*, on the one hand, and chemical action on the other, seem to have been the great agents to which the present aspects of the earth's surface are referable. [CONFORMABLE; UNCONFORMABLE.]

Stratopeite. A mineral found at Pajsberg's iron mine in Sweden. It is, probably, an altered form of Manganese Spar.

Stratum (Lat.). A *stratum* in Geology is a single bed or layer of rock as it lies in the earth. Several such layers together form a group of *strata*, and if compacted and in any way distinguishable from other similar groups, a group of strata forms a *stratified rock*. [STRATIFICATION.]

Stratus. [CLOUD.]

Strawberry. The well-known grateful fruit of the plants of the genus *Fragaria*. Strawberries contain a very small quantity of nutritive matter. The grains or seed-like pericarps are not digestible, and sometimes excite intestinal irritation; so that some physicians have directed their patients to suck strawberries through muslin. [FRAGARIA.]

Streak (A.-Sax. stric). The appearance which arises from scratching a mineral with the point of a knife. The streak is *similar* when the colour of the scratch is the same as that of the mineral, but *dissimilar* when the colour varies.

Stream Tin. Native oxide of tin or Tin-stone, found in rounded particles and masses, mixed with other alluvial matters, in the beds of streams, whence it is obtained by washing. Very little of this ore is now procured from Cornwall, but large quantities of poor quality are exported from the islands of Banca and Billeton in the Malay Archipelago.

Stream Works. Operations intermediate in their nature between mining and quarrying, carried on where there are natural streams of water and gravel in the neighbourhood containing native metal or heavy ore. Gold and tin ore are the substances usually obtained in this way, although lead ore is sometimes also got, and copper ore in one or two cases. The operation of separating the ore from the sands and gravel is simply mechanical, and consists in allowing a current of water to pass over the mixed heap and accumulate the various contents into heaps according to their specific gravity.

Some of the more elaborate contrivances for streaming are ingenious and well adapted for the purpose, but generally the simplest are the most efficacious. Catch pits to receive the mud and slime, and contrivances to regulate the rate of motion of the water, are the chief objects in view.

Strelitz (Russ., plur. strelitzy, said to be derived from strelai; Ital. strale, *an arrow*). A soldier of the ancient Muscovite militia was so called. The strelitzy were the only standing army of the empire; and, like the Turkish janissaries, constantly interfered with its government. Their last revolt was in 1698, during the absence of the Czar Peter I., who, on his return, cashiered the corps altogether.

Strelitzia (after Charlotte of Mecklenburg Strelitz, queen of George III.). A gorgeous-flowered genus of *Musaceæ*, consisting of large herbaceous plants, natives of the Cape of Good Hope. Their foliage consists of long stalked leaves sheathing at the base, arising from a contracted stem, the flower-stalk encircled below by the sheath of the leaf-stalk; while its upper portion gives origin to a large bract or spathe placed obliquely, within which are the flowers. The perianth consists of six segments, in two rows; the three outer ovate lance-shaped, nearly equal, usually of a bright orange colour; the three inner unequal in size; the two front ones bright purple, united together, each one lobed on the outer side, so that the two united petals are distinctly halbert-shaped. The seeds of *S. reginæ* are eaten by the Kaffirs. The fine leaves and large orange and purple flowers render this one of the most splendid of plants. *S. juncea* is remarkable for the usual absence of a blade to the leaf, so that the leafstalks resemble monster rushes.

Strength of Materials. The force with which a solid body resists an effort to separate its particles or destroy their aggregation. [SOLID BODIES, FLOW OF.] There are four different ways in which the strength of a solid body may be overcome: by tension, by compression, by bending, and by twisting. But all these strains may be resolved into strains of extension and compression, which therefore it will be sufficient here to consider. An accurate appreciation of the nature of strains and a sound knowledge of the strength of materials constitute the main part of engineering science; and it is most important, therefore, to every engineering student that these topics should be clearly and accurately apprehended.

In investigating the strength of materials there are three fixed points, varying in each material, of which it is necessary to take note: the ultimate or breaking strength, the elastic or proof strength, and the safe or working strength. Almost every kind of material will be broken in time by an amount of strain that would not suffice to break it at once; and it is necessary, therefore, to give a large margin of strength to all engineering structures, to insure safety. The tensile and crushing strengths of most materials are very different. Thus the ultimate tensile strength of good ordinary wrought iron is about 60,000 lbs. per square inch of section, or over twenty-two tons, while its crushing strength is usually taken in this country at about 16 tons. Of cast iron the average tensile strength is a little over 7 tons per square inch of section, and the crushing strength is over 40 tons per square inch of section. Mr. Hodgkinson found by his ex-

periments that the ultimate resistance of cast iron to crushing varies from 38 to 68 tons per square inch of section, and that 49 tons might be taken as the fair average resistance of good iron. Experiments on the crushing strength of short pieces of wrought iron give a result as high as 29 tons per square inch of section, and Rondelet gives the crushing strength as 35 tons, Weisbach as 25 tons, Claudel as 25 tons, Vose as 21 tons, and Ritter as 19 tons per square inch of section. But the result of experiments on the crushing strengths of cells and tubes does not warrant the adoption of a larger crushing strength than 16 to 18 tons per square inch of section in the case of thick tubes, whereas in the case of thin tubes the crushing strength per square inch is very much less. [TUBULAR BRIDGE.] Steel and homogeneous iron are of about twice the strength of common wrought iron. It was found on testing bars of Howell's homogeneous iron in Mr. Kirkcaldy's testing machine, in 1866, that a bar of this iron required 44·6 tons to tear it asunder, and that it bore a strain of 26 tons without its elastic limit being exceeded; the bar, though stretched like a very stiff spiral spring by this strain, returning to its original length when the strain was removed. The advantage of employing such a material in bridges and other structures of great span is very great, since the greatest part of the load of such structures is to bear their own weight, and if the weight be made one-half less, the strength will necessarily be greatly increased. A bar of homogeneous iron $3\frac{1}{4}$ miles long may be hung up at one end without its working strain being exceeded; or a bar $5\frac{1}{2}$ miles long may be similarly hung up without its breaking strain being exceeded. A telegraphic wire formed of this metal may be carried over a span of 3 miles with a deflection of only one-eighth of the span without its elastic strength of 26 tons per square inch of section being exceeded. Ordinary wrought iron is stretched from $\frac{1}{[illegible]}$ to $\frac{1}{13000}$ of its length for every ton of direct tensile strain per square inch to which it is exposed. Homogeneous metal and steel are stretched only about one-half of this, or about $\frac{1}{16500}$ of their length per square inch of section for every ton of tensile strain. The crushing strength of tubes of homogeneous iron and of cruciform pillars of steel was also tested at Mr. Kirkcaldy's experimenting works in 1866. A tube of homogeneous metal $1\frac{7}{8}$ inch external diameter, $\frac{3}{8}$ of an inch thick, and 4 feet long, bore a strain of 17 tons 3 cwt. per square inch of section, when a slight lateral deflection was observed; and on increasing the strain to 21 tons per square inch of section, the tube yielded laterally and flew out of the machine, though it still remained sound and free from flaw. Four angle irons of steel, $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{5}{16}$ thick, were then riveted together into a cruciform pillar 4 feet long and presenting a cross section of 8 square inches. A compressing force of 370,000 lbs. was applied, or a little over 20 tons per square inch of section, when the pillar was shortened in length ·31 inch, and on the strain being relieved, it remained permanently shorter by ·15 inch. It appears from these and other experiments that the elastic strength of homogeneous iron and steel under compression is not equal to the elastic strength under extension, and this law applies more especially to thin tubes, which crumple up under a moderate strain. Mr. Hodgkinson found that a sheet-iron tube 4 inches square, 10 feet long, and ·03 inch thick, was crumpled up by a load of less than 5 tons per square inch of section.

The theory of the resistance of pillars, which is of great importance on account of its application to architectural purposes, was first investigated by Euler, according to whose hypothesis the strength varies directly as the fourth power of the diameter or side, and inversely as the square of the length. This law is confirmed by the experiments of Mr. Hodgkinson (*Phil. Trans.* 1840) in respect of pillars of wrought iron or timber; but in the case of pillars of cast iron, the powers of the diameter and length were somewhat different. Still Euler's doctrine was confirmed, that if the length of a column exceeds the diameter in a certain ratio, the column will bend and fail by breaking across in precisely the same manner as if it were subjected to a transverse strain. Mr. Hodgkinson found, from a mean of experiments, that a solid uniform pillar of cast iron, whose transverse section is one square inch, is destroyed by a weight of 98,922 lbs., or 44·16 tons. Assuming this as a unit of measure, he gives the following formula (as representing his experiments), in which s is the strength or weight in lbs. that would crush the solid pillar, d the diameter, and l the length; viz. $s = 980922 \times d^{3\cdot55} \div l^{1\cdot7}$. This formula applies to solid pillars of which the lengths are thirty-five times the diameter and upwards, and which are perfectly flat at the ends. When the ends of a pillar are rounded, so that the load bears only on the middle fibres, the strength is greatly reduced. In pillars whose length is thirty times the diameter or upwards, Mr. Hodgkinson found the strength of those with flat ends to be about three times greater than the strength of others of the same dimensions with round ends, the mean ratio being 3·167. In shorter pillars the ratio was not constant. The strength of a pillar is slightly increased by placing discs on the ends to increase the bearings.

In the case of hollow pillars of cast iron, it has been found that the 3·55 power of the internal diameter subtracted from the 3·55 power of the external diameter, and divided by the 1·7 power of the length, will represent the strength very nearly. In the case of hollow pillars or cylindrical tubes of wrought iron, it has been found that the 3·59 power of the internal diameter subtracted from the 3·59 power of the external diameter, and divided by the square of the length, gives a proper expression for the strength. But this rule holds

only when the strain does not exceed 8 or 9 tons on the square inch of section. Beyond 12 or 13 tons per square inch of section, the metal cannot be depended upon to withstand the strain, though 16 or 18 tons per square inch of section will sometimes be sustained. The power of plates to resist compression varies nearly as the cube, or, more accurately, as the 2·878 power of their thickness, the thinnest plates having the least strength. But this law holds only so long as the pressure applied does not exceed from 9 to 12 tons per square inch of section.

The power of iron to resist shocks will not be in all cases proportionate to its power to resist strains. Some cast iron is very hard and brittle, and although it will in this case resist compression, it will be easily broken by an oblique blow. Cast iron, of which the crushing strength is 42 tons per square inch of section, will, if remelted twelve times, bear a crushing weight of 70 tons, and if remelted eighteen times, will bear a crushing weight of 83 tons. But, taking its power to resist impact in its first state at 706, this power will be raised at the twelfth remelting to 1,153, and will be sunk at the eighteenth remelting to 149. Palliser's chilled shot derive most of their remarkable hardness and penetrating power from successive remelting and chilling.

Mr. Hodgkinson gives the following results of his experiments on the resistance to a crushing force of short pillars of some of the most common kinds of wood, the force being applied in the direction of the fibres.

Description of Wood	Strength per Square Inch, in Lbs.
Alder	6,831 to 6,960
Ash	8,683 — 9,363
Bay	7,518 — 7,518
Beech	7,733 — 9,363
English Birch	3,297 — 6,402
Cedar	5,674 — 5,863
Red Deal	5,748 — 6,586
White Deal	6,781 — 7,293
Elder	7,451 — 9,973
Elm	10,331
Fir (Spruce)	6,499 — 6,819
Mahogany	8,198 — 8,198
Oak (Quebec)	4,231 — 5,982
Oak (English)	6,484 — 10,058
Pine (Pitch)	6,790 — 6,790
Pine (Red)	5,395 — 7,518
Poplar	3,107 — 5,124
Plum (Dry)	8,241 — 10,493
Teak	12,101
Walnut	6,063 — 7,227
Willow	2,898 — 6,128

The results in the first column were deduced in each case from experiments upon cylinders of wood turned to one inch diameter and two inches long, flat at the ends. The wood was moderately dry. The second column gives the mean strength from similar specimens after being turned and kept dry in a warm place two months longer. The great difference in the strength frequently seen in the two columns shows strongly the effect of drying upon wood, and the great weakness of wet timber.

The tensile and crushing strengths of various materials, as determined by the best modern authorities, are recorded in the following table:

Tensile and Crushing Strengths of Various Materials per Square Inch of Section.

Material	Tensile Strength in Lbs. per Square Inch of Section	Crushing Strength in Lbs. per Square Inch of Section
Metals.		
Wrought-iron Bars	60,000	27,000 to 37,000
Wrought-iron Plates	52,000	varies as cube of thickness nearly
Wrought-iron Hoops (best)	64,000	
Wrought-iron Wire	70,000 to 100,000	
Cast Iron (average)	16,500	100,000
Cast Iron (toughened)	25,764	130,000
Steel	100,000 to 130,000	260,000
Cast Brass	18,000	10,000
Gun Metal	36,000	
Brass Wire	50,000	
Cast Copper	19,000	
Copper Sheets	30,000	
Copper Bolts	38,000	
Copper Wire	60,000	
Silver (Cast)	40,997	
Gold	20,490	
Tin (Cast)	4,736	
Bismuth (Cast)	3,137	
Zinc	7,000	
Antimony	1,062	
Lead (Sheet)	3,000	
Woods.		
Ash	17,000	9,000
Beech	12,000	9,300
Birch	15,000	6,400
Box	20,000	10,300
Elm	13,000	10,300
Fir (Red Pine)	10,000 to 14,000	5,375 to 6,200
Hornbeam	20,000	7,300
Lance-wood	23,000	
Lignum Vitæ	12,000	9,900
Locust	16,000	
Mahogany	8,000 to 16,000	8,200
Oak	10,000 to 19,000	10,000
Pear	9,800	"
Teak	15,000	12,000
Stones.		
Granite	— —	5,500 to 11,000
Limestone	— —	4,000 to 5,000
Slate	10,000 to 12,000	
Sandstone	— —	4,000 to 5,000
Brick (Weak)	— —	550 to 800
Brick (Strong)	—	1,100
Brick (Fire)	—	1,700
Glass	9,500	
Mortar	50	

Mr. Pole found the German steel wire used for pianofortes to bear as much as 268,800 lbs. per square inch.

The above values are for dry wood. In wet wood the crushing strength is only half as great.

The transverse strength of a beam or girder is determinable by a reference to the tensile and crushing strength of the material of which it is composed. Thus, if a cast-iron girder be supported at the ends and loaded in the middle, the bottom flange will be strained by extension

and the top flange by compression, and the flanges may be regarded as pillars, one of which must be crushed and the other torn before the beam can be broken. Now, as the crushing strength of cast iron is six times greater than its tearing strength, the lower flange of a cast-iron girder is made with six times the quantity of metal contained in the top flange, in order that the breaking forces may be in equilibrium, and so that one flange may not begin to tear before the other begins to crush. By this configuration the utmost strength will be obtained with the least material in the case of cast-iron beams. But as the crushing and tearing strengths of wrought-iron do not follow the same law, wrought-iron beams must not be similarly proportioned; and, in wrought-iron beams or girders, the top and bottom flanges are usually made of about the same cross section.

The clipping or shearing strain to which the cutters of steam engines and the pins of various structures are subjected is a form of tensile strain, as also is the twisting strain to which shafts are exposed. If we suppose a thin tube to possess a transverse section in which the particles cohere more weakly than in the other parts, and if we twist it as we twist the joints of a flute, it is plain that the tube will separate in the weak section, and all the particles in that section will be similarly strained; but if the tube be thick, the outside particles will be strained the most. The strength of solid shafts varies as the cube of the diameter, and the strength of hollow shafts as the cube of the external diameter diminished by the cube of the internal diameter.

Pillars.—If W be the breaking weight of a column or post in tons, l its length in feet, D its external diameter, and d its internal diameter if hollow, then for

Solid pillars of cast iron:

- both ends rounded, $W = 14{\cdot}9\,\dfrac{D^{3\cdot6}}{l^{1\cdot7}}$
- both ends flat, $W = 44{\cdot}16\,\dfrac{D^{3\cdot6}}{l^{1\cdot7}}$

Hollow pillars of cast iron:

- both ends rounded, $W = 13\,\dfrac{D^{3\cdot6} - d^{3\cdot6}}{l^{1\cdot7}}$
- both ends flat, $W = 44{\cdot}34\,\dfrac{D^{3\cdot6} - d^{3\cdot6}}{l^{1\cdot7}}$

Hodgkinson gives the powers as 35·5, but 3·6 is sufficiently near. For solid square pillars of Dantzic oak $W = 10{\cdot}95\dfrac{D^4}{l^2}$, and for similar pillars of red pine $W = 7{\cdot}81\dfrac{D^4}{l^2}$, where D is the side of the square. The safe load is about $\frac{1}{10}$ of the crushing load; the crushing strength of a long cast-iron column being taken at 1,000, that of wrought iron is usually reckoned as 1,745, cast steel 2,518, oak 109, and red pine 78. But short columns of wrought iron, especially if hollow and thin, are much weaker than this proportion assumes. In hollow columns the thickness of the metal should not be less than $\frac{1}{12}$ the diameter.

Girders.—If D = depth of a cast-iron girder at centre in inches, A = area of bottom flange in square inches, S = span in feet, and W = breaking weight in tons; then if the girder be supported at both ends and the load be placed in the middle, $W = \dfrac{25\,A\,D}{S}$, or the breaking weight will be just half of this if the load be equally distributed along the length. A safe deflection is $\frac{1}{40}$ of an inch for each foot in length under a test load of $\frac{1}{3}$ the breaking weight. The working load is never less than $\frac{1}{6}$ the breaking weight in the case of moving loads.

In the case of wrought-iron girders formed of riveted plates, $W = \dfrac{80\,A\,D}{S}$ and area of top flange $= 1{\cdot}18$ A. Wrought-iron girders are now often rolled, and the breaking weights of such girders at 10 feet span are as follow: Depth of girder, or D, 5 inches; size of flange, or F, 2 by $\frac{1}{2}$ inch; breaking weight, or W, 6·6 tons; D 6 inches, F $2\frac{1}{2}$ by $\frac{1}{2}$ inch, W 10 tons; D 7 inches, F 3 by $\frac{1}{2}$ inch, W 14 tons; D 8 inches, F 3 by $\frac{5}{8}$ inch, W 20 tons; D 9 inches, F 4 by $\frac{3}{4}$ inch, W 36 tons; D 10 inches, F $4\frac{1}{2}$ by 1 inch, W 60 tons. With double the span the breaking weights will be just half the foregoing, and so in all other proportions.

Shafts.—The following results, showing the comparative strength of various metals, as ascertained by resistance to torsion, is given by Mr. Rennie. For the law according to which the elasticity is evolved in the case of slender metallic wires or threads of fibrous substances, when the twisting force is less than is necessary to produce a permanent change of structure, see TORSION.

Lead	1,000
Tin	1,438
Copper	4,312
Brass	4,688
Gun metal	5,000
Swedish iron	9,500
English iron	10,125
Cast iron	10,600
Blister steel	16,688
Shear steel	17,063
Cast steel	19,562

Mr. Banks (*On the Power of Machines*) states, as the mean result of several experiments, that a bar of cast iron, one inch square, is wrenched asunder by a weight of 631 lbs. avoirdupois, applied at the extremity of a lever two feet in length. Other experiments on the force of torsion are given by G. Bevan (*Phil. Trans.* 1829) and Savart (*Annales de Chimie*, August 1829).

If the power of a solid cylinder to resist torsion be taken as 1, then the power of a solid square to resist it formed with an equal cross section will be ·87; of a hollow cylinder whose external is to its internal diameter as 4 to 10 is 1·26; as 5 to 10 it is 1·44; as 6 to 10 it is 1·7; as 7 to 10 it is 2·08; and as 8 to 10 it is 2·75,

Hence, hollow shafts are much stronger than solid ones with the same weight of metal.

If L = length of lever in inches to which the force employed to twist a shaft is applied; F = the force applied in lbs.; and D = diameter of shaft if round: then $D = \sqrt[3]{\frac{FL}{1500}}$ for cast iron; $D = \sqrt[3]{\frac{FL}{1700}}$ for wrought iron; and $D = \sqrt[3]{\frac{FL}{3200}}$ for cast steel.

The rule employed by Mr. Watt for determining the proper diameter of the cast-iron fly-wheel shafts of his steam engines is indicated by the following formula: If a be the area of the piston in square inches, p the pressure on each square inch of the piston, and l the length of the crank in feet: then $\sqrt[3]{\frac{apl}{31\cdot4}}$ = the proper diameter to be given to the shaft in inches.

Strepsipterans (a word coined from Gr. *στρέψις, a turning*, and *πτερόν, a wing*). The name given by Kirby to the order of insects which he found to possess rudimental elytra in the form of linear and spirally twisted scales.

Strepsirhina (Gr. *στρέψις*, and *ῥίς, ῥινός, the nose*). A family of Quadrumana, in which the nostrils, situated at the extremity of the nose, are twisted, whence the name. It comprises two subfamilies, the *Lemuridæ* and the *Galeopithecidæ*, which are again divided into various genera, of which *Lichanotus*, *Propithecus*, *Perodicticus*, *Nycticebus*, *Loris*, *Lemur*, *Chirogaleus*, *Otolicnus*, *Microcebus*, *Tarsius*, *Cheiromys*, and *Galeopithecus*, are variously distributed, the metropolis of the family being Madagascar.

Stretcher. In Architecture, a block of stone, or a brick, laid horizontally with its length in the direction of the face of a wall. A stretching course has the bricks or stones in its composition laid horizontally with their length in the direction of the wall. [HEADERS; HEADING COURSE.]

Stretchers. Movable bars across the bottom of a boat for the rowers to place their feet against. The power of the stroke is dependent on the proper adjustment of the stretcher.

Stretching Course. In Architecture, a course in which the bricks or stones are laid horizontally with their lengths in the direction of the face of the wall. [HEADERS; HEADING COURSE.]

Stretching Machine. Calicoes, and other similar textile fabrics, are prepared for the market by being stretched in a proper machine, which lays all their warp and woof yards in parallel positions, and extends their width after the shrinkage caused by bleaching, dyeing, &c.

Stretto (Ital. from Lat. strictus, *strait*, *narrow*). In Music, a term indicating that the measure to which it is affixed is to be performed short and concise, hence quick. It is the opposite of *largo*. The stretto of a fugue is a part coming towards the end, where the answers to the subject are brought more closely together.

Striate (Lat. stria, *a channel* or *furrow*). In Zoology, when a surface is painted or impressed with several narrow transverse streaks.

Striction, Line of. The line of striction on a skew ruled surface is the curve which cuts each generator in the point of the latter which is nearest to the consecutive generator. The line cutting, perpendicularly, two consecutive generators, and upon which their shortest distance is measured, is not itself, in general, a tangent to the line of striction; for the point on a generator nearest to the succeeding one is not necessarily nearest to the preceding one. Such lines, in fact, are generators of a second *conjugate* ruled surface circumscribed to the original one along a curve which is a line of striction on both surfaces. The point in which the line of striction cuts any generator is called the *central point* of the latter; the rectangle is constant whose sides are equal to the distances from this central point to the two points at which any plane through the generator is respectively tangential and normal to the surface; and the normal plane through a generator at its central point touches the surface at infinity. [SKEW SURFACE.] The ruled surfaces of the second order have two systems of rectilinear generators and, of course, a line of striction corresponding to each system. In the hyperbolic paraboloid, for instance, the two lines of striction are parabolas whose planes intersect in the principal axis. In conoid surfaces the rectilinear directrix to which all generators are perpendicular is the line of striction. A familiar instance is the under surface of a spiral staircase; the central axis of the staircase is here the line of striction.

Strigæ (Lat. *furrows*). In Architecture, the flutings of a column.

STRIGÆ. In Botany, close-pressed rigid hairs distributed over the surface. Hence plants furnished with such hairs are said to be *strigose*.

Strigidæ. The name of the family of Nocturnal Raptores of which the owl (*Strix*) is the type.

Strike. Part of the machinery of TRADES' UNIONS. When the executive or committee of an organisation for securing certain advantages to labourers decides that the workmen shall discontinue labour till their claims are satisfied, the act of the labourers is called a *strike*; when, on the other hand, the masters resolve to resist the action of labourers and to enforce certain conclusions which they have come to, and therefore suspend their works, the proceeding is called a *lock-out*.

STRIKE. [DIP AND STRIKE.]

Striking a Tent. Taking down a tent which has been erected or *pitched*.

String (A.-Sax.; Ger. strang). In Music, a cord of some elastic material, which being tightly stretched over two bridges (giving a definite length) and set in vibration, gives a

musical sound. The strings of the violin tribe, and of the harp and guitar, are of catgut; those of the pianoforte are of steel wire. The note sounded by a stretched string depends on three elements; viz. the length and the weight of the vibrating portion, and the tension with which it is stretched. If l = length in inches, and w = weight in lbs. of the vibrating part of the wire; T = the tension, or stretching weight in lbs.; and V = the number of single vibrations per second; then

$$V^2 = 386 \ . \ 156 \frac{T}{lw}.$$

String Board. In Architecture, a board with its face next to the well-hole of a wooden staircase, which receives the ends of the steps; it differs from the *wall string* in its position, the one being near the end wall bearing of the steps, and the other being the outside, or the framing towards their outer end.

String Course. In Architecture, this term is applied to a course running round the face of a building, the projection of which is small in proportion to its height.

Strisores (a word coined from Lat. strideo, *to hum* or *buzz*). An order of birds in the systems of Cabanis and Lilljeborg, including the humming-birds, swifts, night-jars, and kingfishers.

Strobilus (Lat.; Gr. *στρόβιλος*, *anything twisted up*). In Botany, this term is used in describing a fir-cone, which may be defined as a spike of very imperfect flowers, subtended by bracts which are woody and pressed closely to each other. It thus indicates an imbricated scaly inflorescence, or any collection of hard scales, representing distinct flowers arranged spirally, but closely imbricated. The term is applied to any fruit which resembles a fir-cone.

Stroganowite. An altered form of Scapolite, found in loose blocks near the river Sljudänkä in Dauria, of a greyish-white or greenish colour. It is a silicate of alumina, lime, and soda, with about 15 per cent. of chloride of lime. Named after Count Stroganow.

Strombus (Lat.; Gr. *στρόμβος*, literally *a rounded body*, from *στροβέω* and *στρέφω*, *to turn*). The name of a shell-fish in Pliny. This term was applied by Linnæus to a genus of the Vermes Testacea, characterised by the form of the shell, of which the aperture is much dilated, the lips expanding, and produced into a groove leaning to the left. The Mollusca to which this character is applicable form a group of Pectinibranchiate Gasteropods in the system of Cuvier, which has been subdivided into the genera *Strombus* proper, *Pterocera*, Lam., &c.

Stromeyerite. A double sulphide of silver and copper, composed of 15·7 per cent. of sulphur, 52·9 silver, and 31·4 copper. It is isomorphous with Copper Glance, but also occurs compact, of a dark steel-grey colour, with a strong metallic lustre, and is sectile and very brittle. It is found in Siberia, Silesia, Chili, and Peru. Named after Stromeyer, who analysed it.

Stromite. A variety of Diallogite, called after a director of mines of the name of Strom.

Stromnite. A sulphate of baryta and carbonate of strontia: probably a mixture merely of the sulphate and carbonate, found at Stromness in Orkney. It occurs in yellowish-white translucent masses, with a slight pearly lustre, and crystalline cleavage.

Strongylus (Gr. *στρογγύλος*, *round*). A genus of intestinal worms in Rudolphi's classification, characterised by having a cylindrical body, the anal extremity of which, in the male, is surrounded by a kind of pouch of a varied shape, from which is protruded a small filament or spiculum, probably subservient to generation. The mouth is orbicular, sometimes armed with spines, as in the *Strongylus armatus*, which infests the mesenteric arteries of the horse and ass, producing aneurisms; sometimes the mouth is surrounded by tubercles or papillæ, as in the *Strongylus gigas*, which is sometimes found in the kidney of the human subject.

Strontia. An earth contained in a mineral, generally of a pale green tint and radiated crystalline texture, found at Strontian in Argyleshire. It is a carbonate of strontia. Strontia is the oxide of a metallic base, the properties of which are very imperfectly known, called *strontium*; the equivalent of strontia, or oxide of strontium (composed of 44 strontium and 8 oxygen), is 52. It has a caustic taste, an alkaline reaction, and a degree of solubility in water intermediate between lime and baryta. The salts of strontia are generally obtained by dissolving the natural or artificial carbonate in the acids; those which are soluble give the flame of burning bodies a fine rose-red colour: the nitrate of strontia is used for this purpose, and with beautiful effect, in theatrical exhibitions and fireworks. The sulphate of strontia is found native: it is an insoluble white powder when artificially prepared. Some of its native varieties have a pale blue tint, whence the term *cœlestine*. Very beautiful crystals of this variety have been found in the New Red Marl of Clifton and in the neighbourhood of Bristol. A colourless prismatic crystalline variety, of great beauty, is found associated with the native sulphur of Sicily.

Strontianite. Native carbonate of strontia. [STRONTIA.] It occurs in hexahedral prisms which are modified at the edges or terminated by pyramids; also in fibrous, stellated, columnar, globular and granular masses of a green colour; also white, yellow, grey, or brown. It is found at Strontian in Argyleshire, generally in acicular diverging groups of crystals, and in snow-white crystals at Pately Bridge and Nidderdale in Yorkshire. The principal foreign localities are Saxony, Westphalia, the Harz, and the Northern States of America.

Strontianocalcite. A variety of carbonate of lime containing an admixture of strontia.

Strontites. [STRONTIANITE.]

Strophe (Gr. *στροφή*, *a turning*). A division of a Greek choral ode answering to a stanza. The name is derived from *στρέφειν*, *to turn*,

because the singers turned in one direction while they recited that portion of the poem; they then turned round and sang the next portion, which was of exactly the same length and metre as the preceding, and was termed the *antistrophe*. These were sometimes followed by another strophe and antistrophe, sometimes by a single stanza called the EPODE.

Strophiolæ. [CARUNCULA.]

Strophulus (a word coined from the Greek στρέφω, *to turn*, and οὖλα, *the gums*). The *red gum*; an eruption peculiar to infants.

Struma (Lat.). In Botany, a swelling present in some leaves at the extremity of the petiole, where it is connected with the lamina, as in *Mimosa sensitiva*. The term is also used in describing mosses to denote a dilatation or swelling sometimes seen upon one side of the base of the theca.

STRUMA. In Pathology, an enlarged gland.

Strut. In Architecture, a piece of timber placed obliquely to the foot of a king post or a queen post to support a rafter; it is sometimes called a *brace*. The term is also applied to the raking shores inserted to support a building.

Struthein (Gr. στρουθίον, *soap-wort*). A principle obtained from the root of *Gypsophila Struthium*. It appears to be identical with *Saponin*, obtained from the *Saponaria officinalis*, or Soap-wort.

Struthionidæ (Lat. struthio, Gr. στρουθίων, *an ostrich*). The name of a family of terrestrial birds, incapable of flight, with very short or rudimental wings, and long and strong legs; including the ostrich and other congeneric species which constitute the order *Cursores* of Kirby, and the family *Brevipennes* in the system of Cuvier.

Struvite. A name given (in honour of Struve) to the crystallised ammonio-magnesian phosphate found in peat-earth in digging the foundations of the church of St. Nicholas at Hamburg, and which is also met with in guano at Saldanha Bay, on the coast of Africa. It occurs in regular six-sided prisms of a pale yel'ow colour, which are transparent, but generally rendered opaque and blackened by organic matter.

Strychnia or **Strychnine** (Gr. στρύχνος, *nightshade*). A poisonous vegetable alkaloid, discovered in 1818 by Pelletier and Caventou in the seed of the *Strychnos multiflora* [IGNATIUS'S BEAN] and *S. nux vomica*, and also in the Upas poison. Its composition is represented by $C_{42}H_{22}O_4N_2$. To obtain it, the nux vomica seeds are boiled for some hours with water acidulated by one-eighth of its weight of sulphuric acid; they are then bruised, and the liquor expressed. Excess of lime is then added to it, and the precipitate boiled in alcohol of sp. gr. ·850, and filtered hot; strychnia and brucia are deposited together in a coloured and impure state, and may be separated by cold alcohol, which dissolves the brucia. The remaining strychnia is then boiled in alcohol with a little animal charcoal, and the solution filtered boiling hot; on cooling, the strychnia crystallises. The same process is applicable to the Ignatius' beans.

Strychnia is a powerful poison, destroying life with the dose of half a grain. It is a white crystalline solid. It requires 7,000 parts of cold and 2,500 of boiling water for solution: the intensity of its bitterness is such, that an aqueous solution containing not more than $\frac{1}{10000}$ of its weight of strychnia is sensibly bitter. It is soluble in common alcohol, especially at its boiling temperature, and crystallises in prisms and octahedra from this solution. It is dissolved by the acids, forming colourless and crystallisable salts. It is not soluble in the alkalies. Nitric acid does not colour strychnia or its salts, if free from brucia; but it frequently reddens them, owing to traces of brucia.

When a minute quantity of strychnia is moistened with a drop of concentrated sulphuric acid, the strychnia is dissolved without any peculiar colour; but if a minute quantity of peroxide of lead or manganese, or of bichromate of potash, is added, a blue tint is developed, which passes into red and yellow. This reaction is characteristic of strychnia.

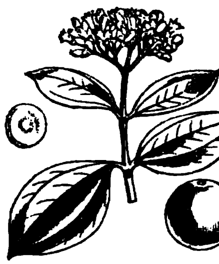
This alkaloid neutralises the acids, and forms very bitter and poisonous salts: they are mostly crystallisable. The caustic alkalies throw down from their solutions a white precipitate of strychnia, which may be dissolved and removed by agitating the liquid with twice its bulk of ether or chloroform. This is the process usually pursued for the extraction of strychnia in cases of poisoning. The liquid is acidulated, concentrated in a water-bath, rendered alkaline by potash, and then shaken with two volumes of ether. The ethereal liquid poured off, and spontaneously evaporated, leaves strychnia.

The symptoms of poisoning by strychnia are difficulty of breathing and sense of suffocation, twitching of the limbs, and violent tetanic convulsions, the body becoming stiff, arched in the back, and resting on the head and heels; the features are convulsed, and attempts to drink are often attended by spasm of the jaws and choking. During the intervals of the paroxysms the intellect is usually clear, but after a succession of fits and shortly before death, there may be loss of consciousness. The only chance of recovery appears to be the very early use of the stomach pump. Medicinally, the extract or tincture of nux vomica is used in certain forms of paralysis and indigestion; and in small doses it acts as a tonic and diuretic. (Taylor *On Poisons*.)

Strychnos (Gr. στρύχνος). A genus of *Loganiaceæ*, consisting of trees or climbing shrubs, natives of the tropics of Asia and America. They have entire strongly-nerved opposite leaves, one of them frequently abortive, and developing from its axil a tendril-like branch; and they bear terminal or axillary corymbs or panicles of greenish-white, generally fragrant flowers. The seeds are flattened, disc-like, and silky, surrounded by pulp.

S. nux vomica is the species which yields the

seeds known under the name of *Nux vomica*. It is a moderate-sized tree, with fruit very like an orange in appearance, and containing numerous seeds of a flattened circular outline, about



Strychnos nux vomica.

the size of a halfpenny, rather thicker near the circumference than elsewhere, the exterior of an ash-grey colour, covered with fine silky hairs, and the interior consisting of very hard grey albumen, in which, near the circumference, the embryo is embedded. The seeds have an intensely bitter taste, owing to the presence of two most energetic poisons, STRYCHNIA and BRUCIA, conjoined with certain peculiar acids; but the pulp is innocuous, and is said to be greedily eaten by birds. The bark of the tree possesses similar properties to the seeds, but in less degree. Serious consequences ensued in the early part of the present century from this bark having been imported and used as Angostura bark; and in Calcutta it is said to be sold for the harmless bark of *Soymida febrifuga*, or Rohun bark.

S. Tieuté, a climbing shrub, growing in Java, yields a juice which is used by the natives for poisoning their arrows. Its effects are precisely similar to those of nux vomica. This poison is called Upas Tieuté. *S. toxifera* also yields a frightful poison called OURARI or Wourali, employed by the natives of Guiana. It has been tried in cases of hydrophobia, but with no good result. *S. Colubrina*, a native of Malabar, furnishes one kind of Snakewood: it is considered by the natives as an infallible remedy in cases of snake-bite; it is also given in fevers and other complaints. *S. ligustrina* and other species are said to yield in Java various kinds of Snakewood, used for similar purposes. *S. Pseudo-Quina*, a native of Brazil, yields Colpache bark, which is largely used in that country in fever cases, and is considered to equal quinine in value; its fruit is edible. It is stated that this species does not contain strychnia, in spite of its bitter taste, and hence it is not considered to be poisonous.

S. potatorum, a tree found in the mountains and forests of India, yields the seeds known in that country as Clearing Nuts. The fruit is black, of the size of a cherry, and contains only a single seed. These seeds are employed to clear muddy water; they are simply rubbed round the inside of the vessel for a minute or two, and then the water is allowed to settle. Their efficacy for this purpose depends, according to Dr. Pereira, on their albumen and casein, which act as fining agents.

Stubble (Ger. stoppel, Lat. stipula). The root ends of stalks of corn, left in the field after the corn has been reaped. In some parts of the country only a small portion of the straw is cut off with the ears of corn, and the stubble in that case is a foot or eighteen inches in length; but in others the corn is cut as close to the surface as possible, and in this case the stubble is quite short. In general, long stubble is a symptom of bad farming, because a quantity of straw is thus left waste in the field, which might have been carried home and rotted into manure.

Stucco (Ital.). In Architecture, a term applied to many sorts of calcareous cements. In this country it denotes generally any third coat of three-coat plaster, consisting of fine lime and sand; the better sort is hand-floated twice, and well trowelled. There is a species called *bastard stucco*, in which a small portion of hair is used. [FINISHING.] *Rough stucco* is merely floated and brushed with water.

Studding Sails. Supplementary sails extended in light winds beyond the leeches of the principal square sails. They are narrow, and of the same height with the sail supplemented. Although not of great power from their size, they exert considerable force on the ship's movements from the leverage which their distance from the mast as centre gives them. They are bent on the studding-sail booms, which are spars run out as required along the upper surfaces of the yards.

Stufa (Ital.). A jet of steam issuing from a fissure in the earth: these jets are not uncommon in volcanic districts. The name is also applied to natural vapour baths, in which steam issues from the earth, generally accompanied by gas, and used for curative purposes.

Stuff (Dutch stof, Ger. stoff, Fr. étoffe). A Commercial term, applied to various woven fabrics; it signifies especially a light woollen cloth formerly much used for curtains and bed furniture.

Stuffing Box. A recess for the reception of packing or stuffing, usually of hemp, and provided with a lid and suitable bolts, by which the packing may be screwed down. The purpose of the contrivance is to enable a rod or shaft to pass through an orifice without any undue friction, and yet to keep the perforation tight. To this end, a stuffing box is provided where the piston rod of an engine passes through the cylinder cover, and also at the point where the screw shaft of a steamer passes through the stern beneath the water.

Sturgeon (Ger. stör, Span. esturion, Fr. esturgeon). The type of a genus of Cartilaginous fishes, with free gills, having the body more or less covered with bony plates in longitudinal rows. The mouth is placed beneath the snout, is small and edentulous, but protractile. Soft feelers or cirri are attached beneath the snout. The bodies of the vertebræ retain

the primitive condition of an undivided gelatinous cord. The sturgeons ascend the larger rivers of Europe in great abundance. The flesh of most of the species is wholesome and agreeable food; their ova are converted into caviare, and their air-bladder affords the finest isinglass.

The sturgeon which is occasionally captured on our east coast is the *Acipenser sturio* of Linnæus.

By statute 16 Edw. II. c. 1, all sturgeon, wherever caught, are declared to vest in the crown by virtue of their dignity, and are to be delivered without purchase. For the importance of the sturgeon fishery in the Caspian, see the *Commercial Dictionary*. No fish, with perhaps the exception of the cod and the herring, has so great an economical importance. [ACIPENSER.]

Sturionians. The name of the family of Cartilaginous fishes of which the sturgeon is the type.

Sturm's Theorem. This theorem, in the theory of equations, enables us to ascertain how many real roots of an equation lie between any given limits. It was communicated to the Academy of Paris, and published in the *Mémoires présentées par des Savants Etrangers* in 1835. In the enunciation of the theorem, to which we shall here limit ourselves (its demonstration being given in every good text-book), it will be necessary to refer to the series of *Sturmian Functions* $F(a)$, $F_1(x)$, . . . $F_m(x)$. The first, $F(x)$ is the function which, put equal to 0, constitutes the given equation, deprived of its equal roots [EQUATIONS, THEORY OF]; and the second $F_2(x)$ is the derived function of $F(x)$. To obtain the other functions, the operation of finding the greatest common measure of $F(x)$ and $F_1(x)$ must be performed with these modifications: 1. The multipliers usually employed in order to avoid fractional coefficients must all be *positive numbers*; 2. The signs of all the coefficients in each remainder must be changed before making it a divisor; 3. The process may be arrested at any such modified remainder $F_m(x)$ which has the property of retaining the same sign for all values of x. This being premised, Sturm's theorem may thus be enunciated: The number of real roots of the equation $F(x)=0$ between given limits a and b is equal to the difference between the numbers of variations of sign presented by the series of Sturmian functions $F(a)$, $F_1(a)$, $F_2(a)$ . . and $F(b)$, $F_1(b)$, $F_2(b)$ . . Thus, if

$$F(x)=x^4-3x^3-2x^2+x-3,$$

we shall have

$$F_1(x)=4x^3-9x^2-4x+1,\ F_2(x)=43x^2+45_9,$$

which is necessarily positive. Putting, for x, $-\infty$ 0, and ∞, successively, the variations in signs presented by the series of three Sturmian functions amount respectively to 2, 1, and 0; hence the equation has two imaginary and two real roots, one of the latter being positive and the other negative. Valuable memoirs on questions relating to Sturm's theorem have been published by Prof. Sylvester; one of these, in the *Philosophical Transactions* for 1853, will well repay the attentive perusal of all students of the higher algebra.

Stuttering. [STAMMERING.]

Stye or **Stythe.** A little boil or tumour projecting from the edge of the eyelid.

Stygmite. A name for a variegated variety of Carnelian of a reddish-yellow colour, and traversed by numerous white lines.

Style (Ital. stile, Ger. stil, Lat. stilus). In Botany, that elongation of the ovarium which supports the stigma. It is an extension of the midrib of the carpellary leaf, or is formed by the rolling up of the attenuated extremity of the latter.

STYLE. In the Calendar, a manner of reckoning time. For the new style introduced by Gregory XIII. in 1582, and adopted by England in 1752, see CALENDAR.

STYLE. In Dialling, the gnomon which projects the shadow on the plane of the dial. [DIAL.]

STYLE. In the Fine Arts, the mode in which an artist forms and expresses his ideas on and of a given subject. It is the form and character that he gives to the expression of his ideas, according to his particular faculties and powers, or his *handwriting*. Style may be almost considered as the refinement of MANNER: it is a characteristic essence by which we distinguish the works of one master from another. From literature this word has passed into the theoretic language of the fine arts; and as in the former we hear of the *sublime*, *brilliant*, *agreeable*, *regular*, *natural*, *confused*, and other styles, so we have almost the same epithets applied to styles of art. Nor is this remarkable, since the principles of taste, in both the one and the other, are founded in nature; and it is a well-known saying, that poetry is a speaking picture. This word is improperly used as applied to colouring and harmony of tints: we speak of the style of a design, of a composition, of draperies, &c.; but not of the style of colouring, but rather the *method* or *manner* of colouring. The definition of this word by Sir Joshua Reynolds is as follows: 'Style in painting is the same as in writing—a power over materials, whether words or colours, by which conceptions or sentiments are conveyed.' But we can scarcely consider this definition sufficiently general; it is rather the *individuality* of the mode of applying this power. There is in art what is called *subjective* and *objective* style. [DECORATION; ORNAMENT; SUBJECTIVE.]

STYLE. A kind of pencil made use of by the Romans for writing on waxed tablets. It was made of brass or iron, with one end sharp for writing, and the other blunt and smooth for making erasures; hence the phrase *to turn the style*, used by ancient writers, signifies to make corrections.

Styles. [RAIL. In Architecture.]

Stylidiaceæ (Stylidium, one of the genera). A small order of monopetalous epigynous Exo-

gens, nearly allied to the irregular-flowered *Campanulaceæ* or *Lobeliaceæ*, of which it has the inferior two-celled ovary and capsular fruit, with numerous albuminous seeds; but it is remarkable for the stamens, two in number, being united with the style in a highly irritable column of curious structure, the stigma lying in a cavity at the apex, surrounded and concealed by the anthers. It consists of small herbs or undershrubs, chiefly Australian. The genus *Stylidium* itself contains the great majority of the species.

Stylite (Gr. στυλίτης, from στῦλος, *a column*). The title given to a peculiar class of anchorites from the places on which they took up their solitary abodes, being the tops of various columns in Syria and Egypt. This strange method of devotion took its rise in the second century, and continued to be practised for a great length of time. The most famous among them was one Simeon, in the fifth century, who is said to have lived thirty-seven years upon various columns of considerable height in the neighbourhood of Antioch. (Montalembert, *Les Moines d'Occident*; *Edinburgh Review*, October 1861, p. 329.)

Stylo. In Physiology, names compounded of this word apply to the muscles attached to the styloid process of the temporal bone.

Stylobate (Gr. στυλοβάτης, *the foot of a column*). In Architecture, the uninterrupted base below a range of columns.

STYLOBATE. A Mineralogical synonym for GEHLENITE.

Styphnic Acid (Gr. στυφνός or στρυφνός, *astringent*). An astringent acid compound obtained by the action of nitric acid upon certain gum resins. It is also called *Nitro-styphnic acid.*

Stypticite. A Mineralogical name for the fibrous form of yellow copperas or Copiapite.

Styptics (Gr. στυπτικός, from στύφω, *to draw together*). In Medicine and Surgery, remedies used for checking the flow of blood. Alum and tannic acid are powerful styptics.

Styracaceæ (Styrax, one of the genera). An order of perigynous Exogens, consisting of trees or shrubs, chiefly tropical, with alternate undivided leaves without stipules, and solitary clustered or paniculate flowers. They are known by their monopetalous flowers, their epipetalous stamens, their long radicle and leafy cotyledons, and by a part at least of the ovules being suspended. The two principal genera, *Symplocos* and *Styrax*, are considered by some botanists as types of two distinct orders.

Styrax officinale, a native of the Levant, &c., yields a balsamic resinous substance known as Storax, which is obtained by stripping off pieces of the bark of the shrub, and submitting them to pressure. In this way liquid storax is obtained. Solid storax appears to be the same substance mixed with fine sawdust and dried. Storax is used by perfumers on account of its agreeable odour, and it is employed in medicine as a stimulating expectorant.

S. Benzoin, a native of Sumatra, Borneo, &c., yields the resin called Benzoin. The juice exudes from incisions made in the trees, and when dried is removed by a knife or chisel. Each tree yields annually about three pounds of benzoin, that which is formed during the first three years being of better quality than that which exudes subsequently. Benzoin is used medicinally in chronic pulmonary disorders, and by perfumers for various purposes. It is also used in the composition of incense.

Styrax. [STORAX.]

Styrole. An oily hydro-carbon obtained by distilling liquid storax. It is perfectly liquid, but has the curious property of becoming a soft viscid transparent solid when heated. In this state it has been called *metastyrole.* The formula of styrole is $C_{16}H_8$.

Styx (Gr. Στύξ, *the hateful*). In the Hesiodic *Theogony*, a daughter of Oceanus and Thetis. This river, Styx, was one of the ten arms or branches of Oceanus. The gods of Olympus swore by the water of Styx, as her reward for aiding Zeus against the Titans. [ACHERON; COCYTUS; LETHE; PHLEGETHON.]

Sub-Apennine Formation. An important group of fossiliferous rocks of the newer Tertiary period, developed on the flanks of the Apennines. They consist of marls containing calcareous matter, and alternating with sand. Near Parma they have a thickness of 2,000 feet. They are very rich in fossil shells of species identical in many cases with those of our crag.

Sub-contrary. In the Scholastic Logic, this term expresses the opposition between two propositions, one of which is a particular affirmative (I), and the other a particular negative (O). [LOGIC.]

Sub-contrary Section. In Geometry, if an oblique cone on a circular base be cut by a plane not parallel to the base, but inclined to the axis, so that the section is a circle, then the section is said to be *sub-contrary.* The part of the cone thus cut off is similar to the whole cone; the plane of the section and the base of the cone being equally inclined to the axis.

Sub-Lieutenant. In the Royal Navy, the rank among combatant officers next below lieutenant, and the first—having a commission—which the youngster attains after entering the service. The former title was MATE.

Subahdar. The Hindu name for the governor of a subah or province. It is also applied to native officers of the Indian army, ranking as captain in European companies.

Subaltern (Lat. sub, *under*, and alternus, *alternate*). Literally an inferior officer, but the name is generally applied to all commissioned officers under the rank of captain. [ENSIGN; LIEUTENANT; &c.]

SUBALTERN. In Logic. [PROPOSITION.]

Subbrachians (Lat. sub, and brachium, *the arm*). The name of the order of Malacopterygious fishes comprising those which have the ventral fins situated either immediately

beneath and between, or a little in front or behind, the pectoral fins.

Subclavian. An Anatomical term applied to vessels, nerves, &c. under the shoulder or armpit.

Subdominant (Lat. sub, *under*, and dominans, *governing*). In Music, that note which is a fifth below the key-note. It is a species of governing note, inasmuch as it requires the tonic to be heard after it in the plagal cadence. In the regular ascending scale of seven notes it is the fourth; the term, however, has its origin from its relation to the tonic as the fifth below.

Subduplicate Ratio. In Arithmetic and Algebra, the subduplicate ratio of two numbers is the ratio of their square roots. Thus, the subduplicate ratio of the numbers 9 and 16 is the ratio of 3 to 4; and of the numbers a and b, it is the ratio of $\sqrt{a}$ to $\sqrt{b}$.

Suber (Lat. the *cork-tree*). The substance known as Cork. It is the epiphlœum of bark, when it acquires an elastic soft texture, and is preternaturally enlarged.

Suberic Acid (Lat. suber, *cork*). An acid substance into which cork is converted by the long-continued action of nitric acid.

Suberin. A name given by Chevreul to the cellular tissue of cork after the various soluble matters have been removed by the action of water and alcohol.

Subgenus. When the species of a genus are so numerous and diversified as to offer characters by which they may be ranged into groups these are termed *subgenera*.

Subinfeudation. In Feudal Law, subinfeudation denotes the creation by a feudal tenant of a subordinate tenancy, to be held of *him* and not of his superior lord. [FEUDAL SYSTEM; TENURE.]

Subito (Ital. and Lat. *suddenly*). In Music, a term of direction; as volti subito, *turn* [the leaf] *quickly*.

Subject (Lat. subjectus, part. of subjicio, *I throw under*). In the Fine Arts, that which it is the desire and aim of the artist to express.

Subject of a Proposition. In Logic, the term of which the other is affirmed or denied. [LOGIC; PROPOSITION; TERM.]

Subjective. In Painting, the term *subjective* is now sometimes used in criticism to indicate that the representation of an object or event is modified by, or *subjected* to, the idiosyncrasy of the artist; and this is in contradistinction to *objective*, when the object is represented with strict individuality. Rubens and Rembrandt were *subjective* painters; the Dutch and Flemish painters of still life, on the other hand, have been *objective* in their works.

Subjective and Objective. Terms expressing the distinction which in analysing every intellectual act we necessarily make between ourselves, the conscious *subject*, and that of which we are conscious, the *object*. 'I know,' and 'something is known by me,' are convertible propositions; every mental act which is not thus resolvable belongs to the emotional part of our nature, as distinguished from the intelligent and percipient. For the distinction between subject and object, the neglect of which has been the cause of infinite confusion and perplexity, we are indebted to the schoolmen, from whom it was derived (through Wolf and Leibnitz) by Kant and the modern German philosophers.

Sublapsarians or **Infralapsarians.** In Ecclesiastical History. The greater number of the divines of the reformed or Calvinist churches have held that God *permitted* the fall of Adam, without positively predetermining it; a doctrine which has been termed *sublapsarian*, in opposition to the high Calvinistic or *supralapsarian* view. [SUPRALAPSARIANS.]

Sublimation (Lat. sublimis, *on high*). A process by which solids are by the aid of heat converted into vapour, which is again condensed, and often in the crystalline form. This operation is frequently resorted to for the purpose of purifying various chemical products, and separating them from substances which are less volatile.

Sublime (Lat. sublimis). In the Fine Arts, high or exalted in style. Sublimity is incompatible with our ideas of elegance, grace, or any of the other sources of beauty, though these may all enter into an object in which these and many other qualities may be combined with sublimity. They have been, however, not unfrequently considered as some of the sources of the sublime. The nod of Jupiter, in the hands of such a master as the Homeric poet, is an indication of sublimity; but when Longinus tells us, that, as applied to literature, the constituent ingredients of sublimity are boldness in thought, the pathetic, proper application of figures, use of tropes and beautiful expressions, and, lastly, musical structure and sounds, we are inclined to think he had very indistinct notions of it himself. We cannot better exemplify the meaning of this term than by referring the reader to the works of Michael Angelo in the Sistine Chapel, wherein, according to Fuseli, 'his line is uniformly grand; character and beauty were admitted only as far as they could be made subservient to grandeur. The child, the female, meanness, deformity, were by him indiscriminately stamped with grandeur. A beggar rose from his hand the patriarch of poverty; his infants teem with the man, his men are giants.' The *terribile via*, hinted at by Agostino Caracci, is the sublime.

Sublingual Glands (Lat. sub, *under*; lingua, *tongue*). A pair of small salivary glands beneath the tongue, the secretion of which is more viscid than that of the parotid glands, and serves to facilitate the passage of the food through the fauces and gullet.

Submarine Telegraph. [TELEGRAPH, SUBMARINE.]

Submaxillary Glands (Lat. sub, *under*, and maxilla, *jaw*). A pair of salivary glands larger than the submaxillary situated beneath or rather behind the lower jaw, but emitting

their secretion, which resembles that of the sublingual glands, below the tongue.

Submediant (Lat. sub, *under*, and medius, *middle*). In Music, the middle note between the tonic and subdominant descending. It is the greater sixth in the major scale, and the lesser sixth in the minor scale.

Submultiple. In Arithmetic and Geometry, the same with *aliquot part* or *measure*; or it is such a part of a quantity as can be expressed by a whole number, as a third, a fourth, &c.

Subnormal (Lat. sub, and norma, *a rule*). In Geometry, that part of the axis of a curve line which is intercepted between the ordinate and the normal. If y be the ordinate, and x the absciss of any curve, the expression for the subnormal is $y\frac{dy}{dx}$. The subnormal is always a third proportional to the subtangent and the ordinate. The term *polar subnormal* has reference to polar co-ordinates, and is applied to the line drawn from the pole perpendicular to the radius vector to meet the normal; its expression is $\frac{dr}{d\theta}$.

Subordinary. In Heraldry, according to some writers on this imaginary science, an ordinary, when it comprises less than one-fifth of the whole shield, is termed a *subordinary*.

Subordination. [TRACERY.]

Subornation (Lat. sub, and orno, *I provide, furnish, procure*; a meaning not classical). Subornation of perjury, in Law, is the procuring a man to take a false oath amounting to perjury. The offence of subornation is not complete unless the oath be taken; but it is a misdemeanour to attempt to procure false testimony.

Subpoena. In Law, a writ of which there are several sorts. *Subpœna ad testificandum* is the common process, both in equity and in the courts of common law, to compel the attendance of a witness. *Subpœna duces tecum* is a writ of the same nature with the former, with a clause requiring the witness to bring with him and produce books and papers. An action of damages lies against parties disobeying this writ.

Subrogation (Lat. subrogo). In Civil Law, the substitution of one person for another in the exercise of rights (whence SURROGATE), but, in particular, the substitution by a creditor of another party to exercise his rights against the debtor.

Subscapular (Lat. sub, *under*; scapula, *blade-bone*). Muscles, vessels, nerves, &c., that lie or pass beneath the scapula.

Subsidence (Lat. subsido, *I sink down*). In many parts of England and elsewhere there is evidence of a depression of the land having taken place, not perhaps within the historic period, but still so recently as to be little, if at all, beyond human experience. As raised beaches are evidences of elevation, so peat and submerged beds of vegetable matter near a sea-coast are proofs of this depression or *subsidence*. Where there is a peat bed still remaining near the sea or only recently washed away, and where peat is continually dug up or drifted in-shore after storms, the peat existing in beds below the level of high water, there is probability of subsidence having taken place. Sometimes the evidence is even more distinct. A general subsidence seems to be going on in those parts of warm seas where the great works of the coral animal are in process of construction. [CORAL ISLAND.]

Subsidy (Lat. subsidium, *an aid*). This term was anciently used to express extraordinary grants to the king, made by authority of parliament. They were very various in character and amount, and were originally levied on the personal estates of those liable to them. Sometimes they were in quantity on all goods, as a tenth, a fifteenth, a thirtieth, the assessment being made by commissioners sworn to execute their office fairly. An ancient example of two such subsidies is to be found in the taxation of the town of Colchester, in the years 1296 and 1301, printed in the Rolls of Parliament. Sometimes they were levied on certain kinds of goods only, as the ninth sheaf, the ninth lamb, the ninth fleece. Sometimes the tax was expressed in kind. Thus, in 1340, parliament granted the king 30,000 sacks of wool as a subsidy for his war against the king of France, and for his recovery of the French crown.

Ultimately, a subsidy came to be considered as a land-tax; tenths and fifteenths being regarded as taxes on personal property, the former on ecclesiastical, the latter on secular, revenues. In the time of Coke a subsidy was reckoned at 70,000*l.*; tenths and fifteenths at 20,000*l.*, the former being at the rate of 4*s.* in the pound on land, the latter at 2*s.* 8*d.* on personal estates. During the first thirty years of Elizabeth's reign, however, a subsidy, as may be learnt from the accounts of the Exchequer, amounted to 100,000*l.* The survey on which the rate was levied was made in 32 Hen. VIII.

After the Revolution, the term *subsidy* was gradually disused. It was necessary to provide larger funds than had been granted during the reigns of the Stuarts, and these were supplied by a land-tax, by customs duties, by a hearth and poll tax, and by the excise. (See, for information on the ancient subsidies, Rastall's *Abridgment*; Davenant's *Essay on Ways and Means*; and the chapter on 'Taxes and Constitutions' in Prof. Rogers' work on *Agriculture and Prices in the Middle Ages*.)

Substance. In Logic and Metaphysics, substance is said to be only the collection or *synthesis* of attributes. 'Attributes,' says Fichte, 'synthetically united, give substance; substance analysed gives attributes.' But in the view of other philosophers, although we can only know substance through attributes, it has nevertheless a real and independent existence; it is 'that unknown, unknowable

substance on which rests all that we experience of the external world.'

Substantive or **Noun Substantive.** In Grammar, that part of speech which denotes a *substance* or *subject*, as distinguished from an *attribute* or *predicate*. [GRAMMAR.]

Substantive Colours. Those colours which, in the process of dyeing, remain fixed or permanent without the intervention of other substances; they are opposed to *adjective colours*, which require to be fixed by certain *intermedes*, or substances which have a joint affinity for the colouring matter and the material to be dyed. [DYEING; MORDANT.]

Substitution (Lat. substitutio, from substituo, *I put under anything*). In Algebra, the replacing of a quantity by another or by a function of several others. The substitution is said to be linear when the variables of a given function are replaced by linear functions of a new set of variables. [LINEAR TRANSFORMATIONS.]

SUBSTITUTION. In Chemistry, this term is applied to such results of affinity as are dependent upon the substitution of one or more atoms of a simple or compound body, for the same or a different number of atoms of another body. Thus, in the decomposition of water, which ensues when sodium is thrown into it, an atom of sodium is *substituted for* (or replaces) an atom of hydrogen, the latter being expelled. These changes are clearly shown by the aid of formulæ. Thus, in the above case,

$$H_2\,O_2 \text{ becomes } H\,Na\,O_2.$$

Another illustrative case of substitution occurs in the conversion of acetic into trichloracetic acid, in which 3 atoms of hydrogen belonging to the acetic acid are substituted by 3 atoms of chlorine:

$$\underbrace{C_4\,H_4\,O_4}_{\text{Acetic acid.}} \text{ becoming } \underbrace{C_4\,Cl_3\,HO_4}_{\text{Chloracetic acid.}}$$

SUBSTITUTION. This term is defined by writers on the Civil Law to be the designation of a second, third, or other heir, to enjoy, in default of a former heir, or after him. Taken in this general sense, it includes all those modes of disposition which are expressed in our law by the terms *entail*, *remainder*, &c. This was also the method of creating what in English law is called a *trust*, in civil law a *fidei commissum*, by *substituting* the person intended really to enjoy the property disposed of, or *cestui que trust*, for the nominal owner or trustee. [FIDEI COMMISSUM; TRUST.]

Substitution, Chord of. In Music, a name given to the chords of the ninth major and minor.

Substratum (Lat. *laid under*). A stratum lying under another. The term *subsoil* is generally applied to the matters which intervene between the surface soils and the rocks on which they rest; thus, clay is the common substratum or subsoil of gravel.

Substyle. In Dialling, the straight line formed by the intersection of the face of the dial with the perpendicular plane which passes through the gnomon. [DIAL.]

Subtangent (Lat. sub, and tango, *I touch*). In Geometry, the part of the axis of a curve intercepted between the tangent and the ordinate. The general expression for the subtangent of any curve is $y\frac{dx}{dy}$.

The *polar subtangent* has reference to polar co-ordinates, and denotes the part intercepted between the tangent and the radius vector upon a line through the pole perpendicular to the radius vector. It is given by the expression $\frac{r^2\,d\theta}{dr}$.

Subtense (Lat. subtensus, part. of subtendo, *I stretch under*). A term sometimes used in Trigonometry to denote the chord of an arc. [CHORD.]

Subtraction (Lat. subtraho, *I draw away*). In Arithmetic, the taking of one number or quantity from another in order to find their difference. The operation is precisely the reverse of addition.

SUBTRACTION. In Law, subtraction is the withdrawal or refusal of a due, as of tithes, or the like.

Subtrahend and **Minuend.** In Arithmetic, two terms which are still occasionally used to denote, respectively, the number to be subtracted and the number to be diminished by the operation of subtraction.

Subulicorns (Lat. subula, *an awl*; cornu, *a horn*). The name of a family of Neuropterous insects, including those which have awl-shaped antennæ.

Subulipalps (Lat. subula, and palpus, *a feeler*). The name of a section of Caraboid beetles, including those which have the exterior palps or feelers awl-shaped.

Subursus (Lat. sub, *under*; ursus, *bear*). The term applied by De Blainville to denote the plantigrade mammalian genera *Meles*, *Taxotherium*, *Palæocyon*, *Ailurus*, *Procyon*, *Nasua*, *Arctictis* (*Ictides*), *Cercoleptes*, and *Amphicyon*, which offer many points of affinity to the true bears (*Ursus*). Many of these minor plantigrades, as *Cercoleptes*, depart from the ursine type, and approach in some manner to the prehensile-tailed *Viverridæ*, e.g. *Paradoxurus*, whilst others, as Amphicyon, are more allied to the old Eocene types.

Succedaneum (Lat.). A medicine or remedy substituted for another.

Succession, Apostolical. In Theology, the alleged uninterrupted succession of priests in the church by regular ordination from the Apostles down to the present day. From this position it has been inferred that the clergy so regularly ordained have a commission from God to preach the gospel, administer the sacraments, and guide the church; that through their ministration only the faithful can derive the grace which is communicated by the sacraments. Hence, according to this view, those

sects of Christians which have no regular succession (having seceded from the Roman Church without retaining ministers regularly ordained, or having subsequently interrupted the succession, i.e. almost all Protestant bodies, except the church of England) have, properly speaking, neither church nor sacraments, since they possess no apostolical authority.

This doctrine is admitted to be of great antiquity in the church; but whether it was known in the first century, is still matter of discussion. As to the historical part of the question, the Epistles of Ignatius are much referred to in support of the doctrine. But these epistles do not declare it in express terms; and the genuineness of these writings is still a disputed point.

At the Reformation, this doctrine was almost entirely lost sight of. The church of England does not affirm it in her articles; but some expressions in her offices have been thought to point more or less distinctly towards it. The first school of Anglican divines did not rely on it in their controversy with Puritanism. They rather rested their argument on the fact, that the church had in early times appointed the episcopal government and regular ordination, and that it could not, therefore, be wise or prudent to swerve from it. It was at this point that Hooker took up the subject; but whether he actually held the tenet, has been much controverted. Mr. Keble (Preface to *Hooker*, p. lxxvii) contends that he did; but, at the same time, admits that there is a marked difference between his language and that of the succeeding school of Laud, Hammond, and Leslie. Under that school, it became the rallying-point of high churchmen, and was zealously maintained by the divines of that section of the church down to, and long after, the Revolution. But since that time it ceased to be brought prominently forward in ecclesiastical controversy, until the rise of the theological school commonly known as the Tractarian.

Succession Duty. A tax imposed by the Succession Duty Act, 1853, on every succession to property, whether real or personal (except those chargeable under the Legacy Duty Acts), according to the value and the relation of the successor to the *predecessor* (the person from whom the interest of the successor is derived). The duty varies according to relationship, as follows: 1 per cent. due from lineal issue, or lineal ancestor; 3 per cent. due from brother or sister, or the descendants of such; 5 per cent. due from father or mother's brother or sister, or the descendants of such; 6 per cent. due from grandfather or grandmother's brother or sister, or the descendants of such; 10 per cent. due from stranger. This Act has in effect charged real property devised by will, and property, whether real or personal, comprised in settlements, with a tax corresponding with the duties on legacies. As regards real property, however, the tax is payable not in respect of the value of the fee simple or capital, but in respect only of the value of the interest of the successor, considered as an annuity for his life.

Succession, Law of. All civilised societies, since they recognise the right of private property as opposed to the communism which characterises a ruder polity [VILLAGE SYSTEM], have also, inevitably, recognised the claim of a deceased person's descendants, and ultimately failing these, of his collateral kindred to the property which he has acquired, and of which he was possessed at his death. Later than the right of succession comes the power of devise, a power which appears to be, according to the opinion of most jurists, a creation of positive law. [WILL.] Both the right of succession and the right of devise are sustained partly on natural equity, partly on economical grounds; the former since the proximity of the relations of a deceased person is a fair ground for a preference being shown to them in distributing the deceased person's estate; the latter since the recognition of such a right or rights by the state is a powerful stimulant to saving, it being thoroughly understood that the general community is benefited by the accumulation of capital made by private persons.

The right being conceded, considerable discrepancies occur in the municipal customs of different communities, and even in different regions comprised within the bounds of the same community, these discrepancies arising generally from the rule which distinguishes landed estate from personal property.

The common law of this country gives the whole of a freehold estate of inheritance to the eldest son, ignoring altogether the other sons and daughters of the deceased person. This appears to be the only community in which the rule of primogeniture is carried so far, and the system or principle affects not only the descendants of the person, who is always technically called the ancestor of those who inherit from him, but his collateral relations, in whose succession males are always preferred to female stocks, and the eldest male of the eldest male stock to all others. Thus, all the relations on the father's side, however remote they may be, are preferred to all the relations on the mother's side, however near they are, where the estate succeeded to is freehold descendible according to the common law.

The rules of succession to such estates were, prior to certain changes introduced by a statute of the year 1834, characterised by two other singular and harsh customs. One was that an inheritance never ascended lineally; in other words, a father could not succeed to his son, though a brother, whose link to the deceased person was contained in the common ancestor (the father), could. This rule was derived from a maxim, *hæreditas nunquam ascendit*; and though the law was relaxed so far as to treat the father as a channel for the brother's inheritance, it was not conceived possible to abrogate the feudal rule so entirely

as to acknowledge a right in the father. The origin of the rule was purely feudal. All estates were conferred by grant or livery, i.e. by actual or symbolical delivery of the estate. If the estate came from anyone but the father, it is clear that there could be no claim of any reversion on the part of the father; if it came from him, the grant was an absolute surrender of all reversionary rights, by virtue of a special statute, known as *Quia emptores*, and the son had equally a new fee.

The other rule, for which no satisfactory explanation has been given, was that half blood could not succeed mutually. Thus, if A dies leaving only a half brother on his father's or mother's side, the rule was that the estate would rather escheat to the crown or the lord, than pass to the half brother. Both these rules were revoked by the Act of 1834.

The common law of succession is not, however, universal. The custom of Kent, known by the name of *gavelkind*, divides landed estates equally, and in a case of succession the eldest son must show that land in this county has been disgavelled, in case he claims as *primogenitus*. Sometimes the same custom prevails in certain manors, in which case the younger brothers must prove the custom, in case they claim to hold as coparceners. Again, in some manors there is a custom that the lands should descend to the youngest son. This remarkable rule, most frequently found in towns, or among burgage tenants, is known by the name of *borough English*, and is, without doubt, a Saxon custom which has survived the Norman law.

Again, the succession of the husband to lands held by the wife, or of the wife to lands held by the husband, varies. Sometimes the husband holds all his wife's lands during his life, provided there be living issue born of the marriage. This is called the *curtesy of England*. In gavelkind lands he holds half only, and on condition that he remains a widower. Again, by common law, the wife's dower is a third of her husband's lands and tenements; by gavelkind custom, the half; in copyholds, it varies in amount, and is called *free bench*.

At a period of English legal history which is not very well defined, the common law was declared to accept the doctrine of representation as opposed to that of proximity. If A dies, and leaves two brothers, it was always admitted that the elder had a prior claim to the younger. But it was not clear, in case the elder of his brothers had also died, leaving issue, that this issue, who were said to represent him, had a preferable claim to the younger brother, who was notoriously nearer to him. Thus, for instance, modern historians have sometimes spoken carelessly of the right of Arthur of Brittany, son of Geoffrey, the nearest brother of Richard I., whose father was dead, as compared with the right of John, youngest brother of the same monarch. But it is clear that at that time John's was considered the better right, and that Arthur's claim would never have been put forward, except to further the intrigues of Philip Augustus. In course of time, however, the other opinion gained ground; and perhaps the leading case, which may be considered to have settled the right of representation over proximity, is the decision on the Scottish crown argued and given at Berwick-on-Tweed, in 1292. The question, however, was considered doubtful for long afterwards, and in fact gave rise to the wars between the houses of York and Lancaster. (Dalrymple *On Feuds*, ch. v.)

The custom of primogeniture has been generally condemned by economists, from Adam Smith downwards. The late Mr. M'Culloch, however, was an advocate of the practice, and an ingenious series of arguments in its favour will be found in the notes which this eminent writer has annexed to his edition of Smith's *Wealth of Nations*. The reasonings for and against the custom are very different when it is interpreted on *economical* or on *political* grounds. It may be defensible on the latter, yet wholly incapable of defence on the former.

The rules of succession to personal estate are borrowed almost entirely from the civil code. In the early ages of English history, personal estate was administered generally by the clergy who were attached to the Roman law. In personal estate the rule of equal partition among persons related in equal degrees to the deceased person, with an absolute preference to relations in the ascending or descending line, and without regard to sex or half blood, has always prevailed. In foreign countries, most of which have accepted the civil code, the rule of succession to real is the same as that to personal estate; and, with scarcely any exception, this rule has been accepted in the United States and the British colonies.

It must always be remembered that in the British Isles, as a matter of fact at the present day, the succession to property is usually regulated by the express provisions of SETTLEMENTS and WILLS rather than by the laws of descent or of distribution in case of intestacy.

The question as to the extent of relationship to which the right of succession should attach, has been debated. Bentham long ago urged that when a man died without a will, and without relations nearer than cousins german in the first degree, the estate should revert to the crown. This view of the great jurist was founded not on purely speculative grounds, but on matters of fact of very considerable public interest. The litigation in favour of remote heirs at law, the attempts made on the most frivolous grounds to upset wills, the general custom of paying costs out of estates, whenever there is the slightest pretext for litigation, and the frequent hardship which the impunity given to vexatious opposition involves, are powerful arguments in favour of annihilating these evils by cutting away all

these contingent rights. There seem to be solid grounds for the belief that infinite good would result from the acceptance of Bentham's suggestion, and that it might be applied to titles as well as to estates.

In the Civil Law, and in those modern systems which are derived from it, there is no distinction between movable and immovable property, considered as a subject of succession. Succession, whether of real or personal property, is either *ab intestato* or by testament. The order of succession ab intestato, according to the civil law [DESCENT], is to be found in the laws of Justinian (*Novell.* 118, 127, &c.). It admits three classes of successors—descendants, ascendants, and collaterals, who are preferred in that order in the succession; so that if a man leave any descendants, all ascendants and collaterals are excluded; and ascendants exclude collaterals, except brothers of the whole blood and their children. The children of the deceased partake equally. Stepchildren are strangers to the succession of their step-parents. Children, the issue of several marriages, succeed equally to the property of their father; but severally to the property of their respective mothers. Grandchildren take *per stirpes*, or by right of representation; i. e. if a child die in the parent's lifetime, his children divide his share equally. Among descendants, he or she of the nearest degree is preferred, and there is no right of representation. Brothers and brothers' children per stirpes divide with parents; but it is doubtful whether more distant ascendants divide with them, or not. Succession among collaterals is said not to extend beyond the tenth degree. The wife (by *Novell.* 53, c. 6) succeeds, under certain circumstances, to a fourth.

Succession, War of the. In Modern European History, two wars, in which great part of the Continent was involved, are commonly known by this name: 1. That of the Spanish succession, occasioned by the dispute whether the succession of Spain should devolve on an Austrian or a French prince (1702–1713); terminated by the peace of Utrecht, which placed the house of Bourbon on the Spanish throne. 2. That of the Austrian succession, in which the right of Charles VI., emperor of Germany, to settle his Austrian dominions on his daughter Maria Theresa, was contested by France, Prussia, Bavaria, and other states; terminated by the peace of Aix-la-Chapelle, 1748.

Succinea (Lat. succinum, *amber*). A genus of fresh-water Gasteropods, so called from the transparent texture and amber colour of the shell. Of this genus, two species (*Succinea amphibia*, Drap., and *S. oblonga*) are British, and are found occasionally in the river Wandle, and in Greenwich marshes.

Succinic Acid (Lat. succinum). An acid obtained among the products of the destructive distillation of amber; when pure, it is a white crystalline substance. Its salts are termed *succinates*; of these the *succinate of ammonia* is occasionally used as a test for iron. It precipitates the peroxide of that metal in the form of a brown insoluble succinate.

Succinite (Lat. succinum). An amber-coloured variety of Lime Garnet [TOPAZOLITE] found in small, rounded, translucent masses, in a serpentine rock in the Viss Valley, Piedmont.

Succory. The *Cichorium Intybus* or *Wild Endive*, called also *Chicory*. The root of this plant, which resembles a carrot, when cut into slices, dried, roasted, and ground into powder, is used for the adulteration of ground coffee. It has a somewhat burnt flavour, slightly resembling that of coffee, but it yields a large quantity of a rich brown infusion, or decoction, with water. To detect the adulteration, sprinkle the suspected article upon the surface of some water in a jar or tumbler: if genuine coffee, it remains for a long time floating, scarcely tinging the water, and appearing greasy or not easily wetted; whereas, if succory powder be present, it communicates a deep reddish-brown tint to the water, and portions of it soon sink to the bottom. [CICHORIUM.]

In order to check the adulteration of coffee by chicory, a Treasury minute of 1852 prohibited the sale of coffee mixed with this material, unless parcels were labelled to the effect that such a mixture had been made. But as chicory was liable to no duty, while coffee was liable, the regulation was ineffectual, and the adulteration was general; and as far as regards coffee supplied in the form of infusion, it was chiefly made of chicory. The legitimate remedy would have been an excise duty levied on chicory, which should be equal in amount to that levied on coffee. This remedy was applied in part in 1860. The duty was raised in 1861, again in 1862 and 1863, and finally settled in 1864 at 24*s.* 3*d.* the cwt.

The flavouring and colouring matter of chicory is wholly destitute of the peculiar properties of coffee; it is, in fact, little else than caramel suspended in woody fibre.

Succubi (Lat.). During the middle ages, this term was used to denote the female devils with which wizards were supposed to have intercourse, in contradistinction to the incubi, or male devils, to whom it was stated that the witches submitted themselves. By the Scotch Highlanders, the succubi are known as the Leannain Lith. (Kirk, *Secret Commonwealth*, 1691.) Lilith, the first wife of Adam, according to the Rabbinical tradition, was regarded as their queen. From her name the word *lullaby* (Lili Abi) is by some supposed to be derived; but this is very doubtful. (Lecky, *History of Rationalism*, ch. i.)

Succursal. In Ecclesiastical usage in various Continental countries, a church established by way of *succour* to a parochial church, regarded as insufficient for the wants of its community: answering to the English *chapel-of-ease.*

Sucker. In Botany, a branch or shoot thrown up by a plant from beneath the surface of the ground, as is common with roses, &c. [PROPAGATION OF PLANTS.]

Sucking Fish. The fish so called is rather a *sticking fish*, since it attaches itself to other fishes, or to the bottoms of vessels, for protection or conveyance, not for drawing anything therefrom by the act of suction. The fish is recognised by the flat oval adhesive disc on the top of the head. It is a comparatively small species, of the *subbrachial division of the Malacopterygians*, in the Cuvierian system; it was called REMORA by the ancients, in reference to its influence—exaggerated in their narrations—in retarding the course of the vessel to which it had attached itself: it is the *Echeneis Remora* of Linnæus.

Sucking Pump. A pump which raises water by exhausting the air from the barrel, and into which vacuous space the water is forced by the pressure of the atmosphere upon the exposed surface of the water. Theoretically, the suction or sucking pump would raise water through a height of 30 feet or a little more, but it is customary (in order to allow for defects of workmanship, &c.) to reckon that the effective height to which water can be raised in this manner is at the most 24 to 26 feet.

Sucrose. A generic name for those sugars which, though identical in composition and properties, are obtained from sources different from that of cane sugar. It includes the sugars of the cane, beet, turnip, carrot, maple, birch, palm, Indian corn, and others less generally known.

Suctorians (Lat. sugo, *I suck*). The name of a tribe of Cartilaginous fishes, comprehending those which, like the lamprey, have a circular mouth adapted for suction.

Sudder (Hin. sadr, *eminence*, *chief*, &c.). A term applied in British India in various significations, but, principally, to the courts of Sudder Adawlut, which were those of highest civil and criminal jurisdiction in all the presidencies, until amalgamated by recent law with the high courts in some of those divisions. A Sudder Ameen is a superior native civil judge or arbitrator, having a jurisdiction previously limited in different localities.

Sudoriparous Glands (Lat. sudor, *sweat*; pario, *I produce*). In Anatomy, the secreting organs of the sweat, which consist of a slender elongated blind glandular tube, coiled into a lobular form and embedded in the subcutaneous fat, and continued thence in a spiral course to the cuticle, where it opens by an oblique pore.

Sudra. [CASTE.]

Suet. The fat situated about the loins and kidneys, which is harder and less fusible than that from other parts of the same animal. That of the ox and sheep is chiefly used; and when melted out of its containing membranes it forms tallow, and is largely used in the manufacture of candles and the ordinary soaps. Beef and mutton suet, when fused, concrete at a temperature of about 100°. Like other kinds of fat, it is a compound of carbon, oxygen, and hydrogen.

Suez Canal. The construction of a canal across the isthmus of Suez, which should connect the Mediterranean with the Red Sea, is a scheme which in one form or other has attracted the attention of governments and private speculators from time immemorial. Nature seems to lend itself to the practical execution of such a canal, for the isthmus is a depression, and a considerable part of the soil is below the level of the two seas. In the time of the ancient Egyptian kings, a canal was constructed, extending from the Nile, near Belbeis, to the gulf of Suez; but this was only for boats, and did not last long. The only serviceable plan seems to be a ship canal from Port Said to the gulf of Suez, a distance of 90 miles. Early in 1856, a concession was granted to M. de Lesseps to construct: 1. A ship canal from sea to sea, 330 feet wide, and sunk 20 feet below the Mediterranean; 2. A canal to the Nile, available for irrigation as well as traffic; 3. Branches for irrigation. The company was constituted in 1859; and considerable progress has now (1866) been made in the execution of the work.

There are three depressions in the line of the proposed canal, one near the Mediterranean, another (Lake Temseh) half-way across, and the third (the Bitter Lakes) a long depression near Suez, which appears in former times to have been the site of a canal. Except two small ridges, one 30, the other 45 feet above the sea, the rest of the line of the projected canal is only 5 to 8 feet above the waters of the Mediterranean. The difference of level between the Red Sea and the Mediterranean is only about 18 feet.

Up to the close of 1865, about four millions and a half sterling had been expended on the works; less than half that sum, however, representing the cost of labour for excavation. The canal had at that time been cut so as to admit the passage of water for most part of the way; but the whole had to be deepened, except where the deep lakes intervene. This work involves the removal of about 60,000,000 cubic mètres of sand and rock, and presents great difficulties. The work of the central part of the canal, near the ridges of Serapium, was about half done. The ports and harbours at the extremities of the canal had hardly been commenced. The original dimensions proposed seem to be no longer adhered to, the width of the part in progress being 58 mètres and the depth 8 mètres. There are very large and costly engineering works still to be executed, and, in fact, the real difficulties seem only now beginning. There does not appear, however, to be any insuperable difficulty in the way of final success, if money can be obtained, and upwards of seven millions sterling of the nominal capital of the company is still available.

Sufferance, Tenancy at or by. In Law, the least or lowest estate which can subsist in

real property; in strictness, a possession only; which arises when a person whose lawful right to occupy has ceased, continues to do so without the agreement or disagreement of the person in whom the right of possession resides.

Suffetes (said to be from the Phœnic. schopetim). Carthaginian magistrates, whose office much resembled that of the Spartan kings and Roman consuls. Their number was two, and they were elected annually from the noblest families of the state. The functions of the suffetes seem to have been confined chiefly to the management of civil affairs. Thus, it was their province to assemble the senate and preside in it, and also to propose the subjects of debate, and collect the votes; but there are instances recorded of suffetes leading the armies of their country. All the cities of note in the Carthaginian dominions had likewise their suffetes; but these, of course, were invested merely with municipal authority. (*Mém. de l'Acad. des Inscr.* vols. xxxiv. xxxviii.; Arnold, *History of Rome*, ch. xxxix.)

Suffragan (Lat. suffragium, *a vote*). In Ecclesiastical usage, every bishop is said to be suffragan, relatively to the archbishop of his province; thus the bishop of Carlisle is suffragan to the archbishop of York, &c. either on account of the suffrages given by them in the provincial synods, or because they cannot be consecrated without the *suffrage* or consent of the archbishop. Titular bishops, ordained to assist a bishop in his spiritual functions, are also commonly, but rather improperly, styled *suffragans*; a title adopted by the stat. 26 Hen. VIII. c. 14, which named twenty-five places for which such suffragans might be appointed. This Act was repealed by 1 & 2 Philip & Mary c. 8, but was revived by 1 Eliz., in whose reign we find notices of suffragans at Dover, Hull, and elsewhere. This law, which has not been acted on for upwards of two centuries, is still unrepealed. [CHOREPISCOPI.]

Suffrage (Lat. suffragium). In all communities which are not governed despotically, and which possess an administration, the assent of the people either in whole or part is invited, either to the election of magistrates, senators, legislators, and the like, or to the passing of laws, or both. This was the case with the ancient states of Greece and Rome, and the Tyrian colonies in so far as we are acquainted with their constitution. At Athens, the freest state of antiquity, the whole free native population was invited to elect magistrates, to pass laws, and even to decide party contests by the singular machinery of OSTRACISM. At Sparta, the institutions of which were rigid and unyielding, the assembly of the Spartans, who alone were possessed of political rights, elected the annual officers, called EPHORI, who gradually appropriated the chief part of the administration. Even when the constitution was aristocratic, the electoral power remained with the people, though the franchise was limited and the opportunity for exercising it still more so. In Rome, the suffrage was more complicated, and as its machinery is not exactly described by those who lived while it operated, its distribution is more obscure. But the people elected magistrates and passed laws. Those who had been elected were, as a matter of course, drafted into the senate, this body having, in certain directions and on certain occasions, a legislative power. Similar or analogous arrangements are made in the Italian republics.

The electoral franchise in the larger states of the modern world is reputed to have been derived from the councils of the church and the election of ecclesiastical officers. There seems little doubt that, in the early history of Christian communities, the election of officers was in the hands of the mass of believers. Persecuted and poor, forced to perform their rites in secret, and liable perpetually to charges of treason, the early Christians were driven to establish equality in the community; and when the church was acknowledged by the empire, the form at least of an election remained. In the councils the process was even more enduring; and as the clergy met in order to enforce discipline, and occasionally to aid the exigencies of the sovereign, the developement of a parliamentary system was effected long before a similar method was adopted for the laity. Forms of election, suffrages given on important matters of domestic economy, were familiar in the manor courts, and when the suffrage was given, it was no novelty in fact, though its immediate purpose was a novelty by no means agreeable to the recipients. (See a somewhat imaginative scene in Palgrave's *Merchant and Friar*, in which a mediæval election is described.)

It is not easy to determine on what persons the suffrage was conferred in the earliest times. In all likelihood, as the election of knights and burgesses was simply that they might make grants to the crown, and be in consequence permitted to petition for redress of grievances, all who were liable to taxation would be electors. For instance, the number of persons assessed to the tax in the borough of Colchester, in the year 1301, is 391. There is, probably, no reason to doubt that each and all of these persons (in pursuance of the terms of the great charter, that no freeman should be taxed without his consent) were empowered to register votes for any candidate whom they might think proper to elect, and to whom they might pay the modest wages of parliamentary attendance.

Towards the close of the fourteenth century, the representative in parliament, and especially the knight of the shire, became a far more important personage than he was at the first institution of parliament. Hence a seat in the House of Commons became an object of ambition, and no small value was attached to the franchise. In order, it seems, to put a stop to undue returns by the sheriff, a declaratory statute was passed (8 Hen. IV.) Dec. 1406,

by which, notice having been given fifteen days previous to the day of election, the 'suitors at the county court' were invested with the suffrage. Who these suitors were, has been much debated, but on the whole it seems likely that all possessors of estates of inheritance were included in the term. In the year 1430, however, the Commons petition, that whereas 'knights of the shire had of late been chosen by outrageous and excessive numbers of people and of small substance, who crowded tumultuously to county elections,' it would be desirable to limit the suffrage to holders in free tenements of the annual value of forty shillings. There is no doubt that this limitation of the county franchise was reactionary, but it does not appear that any similar limitation was put on the boroughs.

A variety of customs crept up in these boroughs, and the suffrage was very differently awarded. In some it was confined to the corporation, in most to the freemen; or it was extended to all residents paying scot and lot, i.e. local taxes. In some, as at Preston, it was universal.

These anomalies were remedied by the Act of 1832, commonly called the Reform Bill. As a rule, the potwallers or potwallopers, i.e. those who had any habitation in the borough, or, in the homely meaning of the word, boiled a pot in it, were extinguished. The freemen were retained, but could exercise their franchise only if they resided within a few miles of the borough, while the rental qualification of 10*l.* per annum, with certain conditions intended to obviate the sudden creation of voters, and securing the payment of local taxes, was created. In the counties, the freeholders were supplemented by copyholders possessing a certain amount of clear annual value, and by occupiers to the amount of 50*l.* and upwards, the last being inserted on the electoral roll by the so-called Chandos Clause.

Of late years, many projects have been put forward for an extension of the suffrage, some being the demands of parties outside parliament, some being government bills. All have hitherto failed. The 'Chartists' represented twenty years ago the principle of universal suffrage, but their organisation broke down, and is only now reviving under another form. The latest suggestion made by an administration was that of the Russell-Gladstone cabinet, which proposed 14*l.* for the counties and a 7*l.* rental for the boroughs. The House of Commons, however, substituted a rating for a rental clause, on the motion of Lord Dunkellin, and the government resigned. It appears, however, to be agreed on all hands, that the settlement of the question is only temporarily postponed, and that some decision must be speedily arrived at which shall, if possible, be final. [Reform; Representation.]

Suffrago (Lat. suffrago, *the pastern*). In Mammalogy and Ornithology, the joint of the tibia with the tarsus.

Suffruticose (Lat. sub; frutex, *a shrub*). In Botany, this term is applied to any plant which is not exactly either a shrub or an herbaceous plant; i.e. which has not hard woody twigs and complete buds like the one, nor perishable succulent twigs like the other. Lavender is an instance of a suffruticose plant.

Sufi. [Sofi.]

Sugar (Fr. sucre, Ger. zucker). A crystallised substance, obtained in greatest plenty from certain varieties of tropical grasses, but present to some extent in all grasses, and found in an infinite variety of other plants. The specific characteristic of all sugars is that they contain carbon, hydrogen, and oxygen only, and in definite proportions. One kind of sugar only is fermentable, this being called *glucose* or *grape sugar*. Some other kinds, as cane sugar and sugar of milk, may by particular processes be turned into glucose, and be made by means of one fermenting process to yield alcohol, and by another and subsequent process vinegar. [Acer; Beet; Saccharum.]

In his *History of Sugar and Sugar-yielding Plants*, Mr. Reed states that the sugar cane was first made known in the West by the conquests of Alexander the Great; Nearchus, the admiral sent down the Indus, describing it as a kind of honey growing in canes or reeds. From India the sugar cane was introduced into Arabia, Egypt, and the western parts of Asia. Dioscorides, in the first century of the Christian era, is said to be the first writer who uses the word *saccharum*, or sugar, a word which may be identified with the Sanscrit çarkara, and perhaps the Hebrew shakar and the Malay jagara. The Greek term is σάκχαρ. Pliny remarks that sugar in his time was used for medicine only. In the seventh century, the physician Paulus Ægineta describes sugar as the Indian salt, and recommends that a piece be kept in the mouth during fevers. The sugar cane was known in the Morea, Rhodes, Malta, and Syria, before the time of the Crusades; and there is evidence that it was introduced into Sicily between 1060 and 1090. It was brought into Spain by the Moors, on their conquest of the country early in the eighth century; and a large amount of sugar is still manufactured in the tract which lies between the Sierra Nevada and the sea; the chief seat of the manufacture being at Almuñecar. In the beginning of the fourteenth century, sugar, according to Sanuto, was supplied from Sicily, Cyprus, Crete, Malta, and Alexandria. That of Cyprus and Alexandria was the cheapest, but it was always exceedingly dear. The price of sugar bought at this period in England was on an average 1*s.* 4½*d.* the pound troy. (Prof. Rogers, *On Agriculture and Prices in England*.) Sugar continued long to be the choice luxury of the rich.

In 1506, sugar was introduced into the Canary Islands, and thence was taken to the islands of the Mexican Gulf. It has become in an eminent degree the produce of the intertropical regions of the New World, though the production of this necessary of life is increasing in some parts of India and the islands of the

Indian seas. It has been prepared from time immemorial in China; but, cheap as labour is in that fertile and populous region, the Chinese do not seem able to compete with the more favourable climate and the greater mechanical appliances and skill possessed by the sugar planters of the Leeward Islands and Brazil.

According to some, the sugar cane is indigenous in America and the West Indies; while others maintain that it was not known until transplanted thither by Europeans. In Hispaniola, according to Peter Martyr, the sugar cane was known in 1493: it was introduced into Madeira from Sicily in 1420. In 1641, sugar canes were transplanted from Brazil to Barbadoes, but the sugar there made was at first so bad as to be scarcely worth exporting. By 1676, however, the manufacture had been so far improved and the trade had so increased as to employ 400 vessels, averaging 150 tons burden.

The first account of a shipment of sugar to England, is apparently one from Venice, of 100,000 lbs., in 1319, and during the two succeeding centuries it was imported in small quantities, but chiefly for medicinal purposes. In 1653, Hawkins, the navigator, brought sugar to England from St. Domingo; but it came into general demand only on the introduction of tea and coffee.

The process, as carried on in our West India islands, consists in pressing out the juice by rolling mills, and carefully evaporating it till it has acquired the proper consistency for crystallising; lime water is added during this operation, to neutralise any free acid, and to facilitate the separation of certain vegetable matters, which, in consequence of the action of the lime, rise more readily to the surface, and admit of being skimmed off. When duly concentrated, the syrup is run off into shallow wooden coolers, where it concretes; it is then put into barrels with holes in the bottom, through which a quantity of treacle or molasses gradually drips, and the remaining sugar acquires the granular crystalline state; it is packed into hogsheads, and comes to us under the name of *raw* or muscovado sugar. [SUGAR REFINING.]

The chemical characters of sugar are well defined, especially those of the crystallisable or cane sugar. Its specific gravity is about 1 6. It dissolves in all proportions in water, is less soluble in alcohol, and is recognised by its purely sweet taste. It is blackened by sulphuric acid; and when about one part of this acid is added to two of thick syrup, the mixture presently boils up into a black frothy mass, which is little else than carbon, acid, and water. In respect to ultimate composition, sugar belongs to that important class of proximate vegetable principles which are theoretically regarded as compounds of carbon and water; i. e. of carbon and oxygen and hydrogen, in the same relative proportions as they exist in water. The following shows the results of numerous analyses of the finest loaf sugar in a dry and pure state, with its atomic constitution:—

	Atoms	Theory	Expt.
Carbon	24	42·11	42·85
Hydrogen	22	6·43	6·35
Oxygen	22	51·46	50·80
	68	100·00	100·00

Several other varieties of sugar have been chemically examined; such as grape sugar, honey sugar, mushroom sugar, manna, liquorice sugar, &c.

Total Imports of Refined Sugar and Sugar Candy,

	1860	1861	1862	1863	1864
Unrefined and refined sugar and sugar candy from all parts	cwt. 344,089 9,140,198	cwt. 241,795 10,620,859	cwt. 321,409 10,181,257	cwt. 296,676 10,999,361	cwt. 925,694 11,605,882
Total	9,484,287	10,862,654	10,502,666	11,296,037	12,531,576

Imports of Unrefined Sugar from all Parts not mentioned in the following Table, and chiefly from the foreign West India Islands, Brazil, and the Philippine Islands.

	1860	1861	1862	1863	1864
From British West Indies, &c., as shown in preceding table	cwt. 3,495,892 5,300,217	cwt. 4,434,570 5,944,494	cwt. 4,901,241 4,958,607	cwt. 5,151,857 5,550,831	cwt. 5,557,733 5,122,455
Total from all parts . .	8,796,109	10,379,064	9,859,848	10,702,682	10,680,188

The principal European crops raised in Germany (Zollverein), France, Austria, Russia, and Belgium, amounted in 1860–1 to 329,000 tons, in 1861–2 to 364,000 tons, in 1862–3 to 405,000 tons, in 1863–4 to 349,000 tons, and in 1864–5 to 442,000 tons.

Imports of Raw Sugar into the United Kingdom from British Possessions, from 1860 *to* 1864, *inclusive.*

	1860	1861	1862	1863	1864
	cwt.	cwt.	cwt.	cwt.	cwt.
Antigua	185,586	163,648	258,405	202,483	52,365
Barbadoes	647,051	794,117	701,255	649,969	539,706
Dominica	61,125	66,013	57,442	50,568	40,631
Grenada	91,974	83,498	58,200	90,181	85,384
Jamaica	520,808	523,676	553,013	514,555	471,521
Montserrat	328	2,917	5,117	6,647	7,967
Nevis	25,736	30,019	35,733	39,424	16,149
St. Christopher . .	165,225	154,598	186,913	200,691	96,890
St. Lucia	72,940	95,747	97,367	95,711	85,822
St. Vincent	138,332	135,181	145,288	136,253	123,346
Tobago	51,482	55,336	72,303	47,533	44,357
Tortola	...	...	1,748	...	...
Trinidad	530,533	530,009	687,300	600,482	670,793
Bahamas	...	4,514	670	...	1
Bermudas	...	2,922	...	360	3
Demerara	777,368	923,796	873,588	889,087	925,993
Berbice	107,122	124,306	130,429	97,939	99,334
Total from British West Indies and British Guiana . .	3,376,610	3,690,297	3,864,771	3,621,883	3,260,262
Mauritius	1,163,732	1,503,691	686,433	1,635,671	1,054,429
Bengal	364,976	419,637	101,006	14,315	481,350
Madras	289,034	250,228	207,710	218,566	228,223
Bombay	1,038	1,163	45	343	1,553
Penang	76,044	included with Singapore	...	...	...
Ceylon	4	5	1	2	1
Singapore	29,779	79,203 including Penang	98,641	60,051	96,637
Total	5,300,217	5,944,494	4,958,607	5,550,831	5,122,455

Statement showing the Net Revenue, and the Average Price, inclusive and exclusive of Duty, from 1860 *to* 1864 *inclusive.*

Years	Net Revenue	Average Rate of Duty			Average Price per Cwt. in Bond			Average Price per Cwt. inclusive of Duty		
	£	£	s.	d.	£	s.	d.	£	s.	d.
1860	5,833,484	0	13	4	1	7	2	2	0	6
1861	6,104,325	0	13	4	1	5	8	1	17	0
1862	6,215,346	0	13	4	1	5	0	1	18	6
1863	6,249,815	0	13	4	1	5	2	2	0	9
1864	5,157,083	0	11	1	1	6	3	1	19	4

The diminution of the revenue in 1864, as compared with the years immediately preceding, is owing to the reduced rates of duty which took effect in that year.

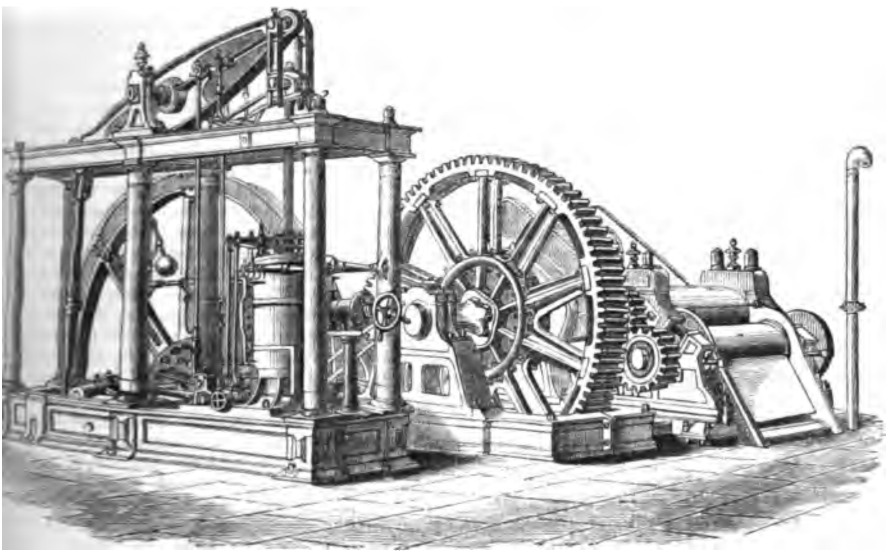
Sugar Candy. Sugar clarified, and rendered transparent by crystallisation.

Sugar Cane. [SACCHARUM.]

Sugar Mill. A mill for expressing the juice from sugar canes, consisting usually of three horizontal iron rollers, two of which are set on the same horizontal plane, while the third is set over and between the other two, so as to touch both. The canes are fed in between the top roller and one of the lower ones, and there receive the first squeeze. The juice runs down into a trough formed in the base of the mill; and the canes travel on and receive their second squeeze between the top roller and the second horizontal one, after which, the juice being all squeezed out, the residual woolly fibre, known as *begass*, is used as fuel beneath the boiler of the engine that drives the mill. An approved form of sugar mill, with bêam engine for driving it, is shown in the annexed figure. Such mills are now made of very large size, and the most material condition of their efficiency is great strength in the working parts, so as to obviate as far as possible the risk of injury or stoppage even when subjected to the rough usage to which these mills are exposed. A friction coupling, set in some convenient part of the mill, between the fly-wheel and the rollers, would be a useful expedient, as it could be screwed up so as to transmit the motion of the engine

when the mill was in the ordinary course of working, but yet to slip when accidentally subjected to very severe strains.

An engine of 20 horse-power will work a *sugar mill* having rollers 5 feet long and 28 inches diameter, the rollers making $2\frac{1}{2}$ turns per minute. An engine of 18 horse-power will work a mill with rollers $4\frac{1}{2}$ feet long and 26 inches diameter, and an engine of 16 horse-power a mill with rollers 3 feet 8 inches long. Twelve horse-power will work a mill of which the rollers are 4 feet 2 inches long and 24 inches diameter, and 10 horse-power a mill with rollers 3 feet 10 inches long and 23 inches diameter. It will require an engine of 25 to 30 horse-power to drive a mill with rollers $5\frac{1}{2}$ feet long, 30 inches diameter, and making $2\frac{1}{4}$ turns per minute. Such a mill will express the juice out of 130 tons of canes in from 12 to 15 hours. An acre of land produces from 10 to 20 tons of canes, according to the locality and the age of the canes. The juice expressed from the canes will stand at from 1·8° to 12° of the saccharometer, according to the locality and other circumstances. The weight of sugar produced



Sugar Mill.

varies from 6 to 10 per cent. of the weight of the canes. Well-constructed mills give in juice from 60 to 70 per cent. of the weight of the canes; and in no case should the surface of the rollers move at a greater speed than 16 feet per second, else the necessary *time* for the expression of the juice will not be afforded, and a much less per-centage in proportion to the weight of the canes passed through will be obtained. At one time, sugar mills with vertical rollers were much employed, and motion was given to them by a pole, the end of which was moved round by a horse in a circular path. But the difficulty of feeding such rollers evenly with canes was so great as to cause the general abandonment of that species of mill. The framing of sugar mills is generally made of cast iron, and the rollers are of cast iron, but the spindles on which they turn are of wrought iron.

Sugar Refining. The series of operations by which white or refined sugar is produced from brown or raw sugar. The cane juice, after having been expressed by the sugar mill, is conducted into a caldron or clarifier holding from 300 to 400 gallons, where it is heated, and a scum is thrown up and removed, after which the liquor is evaporated to the consistency of syrup in a series of evaporating pans, of which the last is called the *teache*. When the syrup is sufficiently concentrated, it is poured into square wooden boxes, where it sets, and is then placed in hogsheads perforated at the bottom to enable the molasses to drain out. The sugar thus obtained is raw sugar, and on its arrival in this country it is dissolved in water heated by steam, filtered through bag filters to remove all refuse, and then passed through a deep stratum of animal charcoal, not reduced to dust, but granulated like coarse gunpowder. The charcoal takes away a large part of the colour of the syrup, and leaves it almost colourless. The syrup is then evaporated in a pan called a *vacuum pan*, which consists of a pan or vessel, generally of copper, heated by a convolution of steam pipes placed within it, and fitted with an air-tight cover: a vacuum being maintained within the pan by condensing the steam as it is raised from the syrup by the action of the heated coil. This condensation is effected by means of a jet of water in

a contiguous vessel, into which a pipe from the pan opens. The water so introduced is pumped away by an air pump, or, as it is called, a *vacuum pump* (resembling in all respects the air pump used in steam engines), the existence of the vacuum being thus constantly maintained. Boiling in vacuo has the effect of enabling the vaporisation to be carried on at a lower temperature, and therefore with less carbonisation of the sugar than would otherwise take place. When the syrup has been boiled sufficiently for granulation to take place, a plug is pulled out in the top of the pan to enable air to enter, and by opening a cock in the bottom of the pan the syrup is drawn off into a vessel beneath, whence it is ladled into conical moulds, open at the base and with a small hole at the apex which so long as the sugar is liquid is kept stopped up. When the sugar is set, the small orifice at the apex of the mould is opened, and a mixture of sugar and water is poured over the base of the cone, which is kept uppermost, while the apex is suffered to drip into a vessel placed beneath. The water in the syrup penetrates through the mass, and washes away any treacle or colouring matter which may remain in the mass; for it is the property of this colouring matter to spread itself over the surface of the crystals, but not to enter into their composition, and it may consequently be, for the most part, washed away by water suitably applied. Dark brown sugar spread upon a frame of wire gauze, beneath which a vacuum is maintained, is rapidly whitened if sprinkled with water out of the rose of a watering pot, the treacle being carried away with the water. Molasses, as it arrives in this country from abroad, generally contains a good deal of sugar, which is extracted by boiling the molasses and emptying it into moulds, when the treacle drips away, leaving within the mould a coarse brown sugar, which is again dissolved, passed through charcoal, and crystallised in the manner already described.

In refining sugar, the sugar should be turned out with a large grain. This end is promoted by bringing the liquor first introduced into the pan to the crystallising point. Instead of emptying it and taking in a new supply, this liquor is retained in the pan, new supplies being from time to time added as the water is evaporated, so as to keep the pan constantly full. By this method, the crystals first formed in the pan become nuclei about which the particles of sugar subsequenlty added may arrange themselves, and as there are thus fewer crystals each of them is larger. It is usual to allow the temperature of the pan to rise just before the liquid sugar is run out, by partially turning off the injection. Any very small crystals are thus dissolved, and instead of forming themselves anew the particles go to increase the size of the larger crystals. In former times, blood was used in sugar refining, but its employment has now been long discontinued.

The action of animal charcoal in bleaching syrups and other liquids is not well understood; but it appears to be owing to the presence of the charcoal in the bones deoxidising the phosphates and other substances which enter into their composition; these substances again slowly oxidise by contact with the liquid, from which they take oxygen, leaving the equivalent of hydrogen in the nascent state, which combines with the free charcoal or colouring matter of the liquid, forming with it a colourless compound. The charcoal filters employed in sugar houses are often 20 feet deep or more. After a certain period of use, the charcoal loses its bleaching power. It must then be removed from the filters, and reburnt, when the bleaching power is restored; but after several repetitions of this process this power is lost altogether. Latterly, centrifugal machines for drying the sugar have been introduced in sugar refining. These consist of cylinders of wire gauze, which are put into rapid rotation, and the wet sugar being placed in these cylinders the liquid is ejected at the circumference by the centrifugal force. In some places abroad the sugar is refined at the same time that it is made. To defecate 330 gallons of juice, 6 boiling pans or clarifiers, 4 scum presses, and 10 filters are needed; and to granulate the sugar, two vacuum pans are required, 6½ feet in diameter, with two condensers, and it is better to have also two air-pumps. Three cylindrical boilers of 6 feet diameter will generate the steam required to boil the liquor in the vacuum pans; and 10 centrifugal machines, driven by a 12-horse engine, which will also drive a pair of crushing rollers, will be requisite to whiten the sugar by wetting it and again drying it by centrifugal force. The three modern improvements in sugar refining are: the vacuum pan, which diminishes carbonisation; the use of animal charcoal for bleaching; and the centrifugal machine.

Suicide or **Self-murder** (a word coined from Lat. sui, *self*, and cædo, *to kill*). Few chapters in the history of the human mind are more singular than that of suicide, as showing the kind of honour and estimation which a practice so unnatural has attained in the feelings of many nations. The rank which religious suicide has held from immemorial antiquity, and still holds, in the opinion of the Hindus, has been too often described, and is too familiar in its most notorious and painful instances, to need more than adverting to on the present occasion. It is said that the practice is condemned by their older books; if so, the traditionary sentiments of the people have been formed on some different model. The suicides of the Hindus have proceeded partly from fanaticism, partly from an apathetic philosophy, those of the ancient Scandinavians, esteemed equally honourable, from the temper of warriors, who could endure any evil except the approach of helpless and unwarlike old age.

Among the Greeks, the first enquirers who reasoned out the principles of human life and action by a train of philosophical investigation, singularly vague and discrepant opinions on this subject seem to have prevailed. Socrates, the great master of ethics, was emphatic in his condemnation of suicide. Plato speaks in a more dubious strain. Writing as a lawgiver, he reprobates it; and in his arguments on the subject is to be found the well-known illustration which has figured ever since in all such discussions, in which he compares it to the desertion by a soldier of his post; yet he expressly excepts from his censure those cases in which it is committed under the pressure of immitigable calamity. Pythagoras, at an earlier period, denied its lawfulness. (*Athenæus*, l. iv.) In the later days of Greek philosophy, both Stoics and Epicureans found arguments for its defence in their respective principles. The former sect was notorious for its tenets on this subject; Zeno and Cleanthes, its great masters, having both put an end to their own lives, as Democritus had done before them, from the mere tedium of old age.

> Cum jam matura vetustas
> Admonuit memorem motus languescere mentis,
> Sponte suâ letho caput obvius obtulit ipse.

The argument of an Epicurean philosopher on the topic may be collected from Cic. *Tusc. Disp.* v. 41; and, indeed, may be compressed in the pithy Greek motto for a drinking party, Ἢ πῖθι, ἢ ἄπιθι—*drink, or begone.* The influence of Greek philosophy had, as is well known, a great share in producing that tendency to suicide which distinguished the higher society of Rome in the later days of the commonwealth. The 'Roman death,' as it is emphatically called, was not really a national habit; the older manners of the commonwealth repudiated it; its prevalence was owing to foreign doctrines, acting on minds affected by the violent passions, engrossing luxuries, and rapid vicissitudes of fortune which distinguished that era. Virgil returns to the Pythagorean view; and, without inveighing against suicide, represents it as a sad and mournful death, the perpetrators of which are doomed to a long and shadowy existence—without torment, but without enjoyment; one which they would willingly exchange for the bitterest poverty and labour in the cheerful light of day. At a later period, suicide committed by criminals under accusation was made criminal by the Roman law. This was with a view to preserve the forfeiture of the criminal's property to the government. Suicide, as such, does not seem to have been the subject of legislation.

Although Christianity was not slow in effecting a reform in the feelings of mankind on this subject, yet some relics of the ancient sentiments lingered awhile, even in the minds of enlightened believers. The fanatical Donatists were greatly addicted to suicide, and are justly condemned on this account among others by the early writers of the church, who considered suicide lawful only when committed by virgins to preserve their chastity. The cherished sentiments of the fathers of the church on this subject rendered them lenient to such victims of honour, and some of them have even gone so far as to commend them. Augustine only pities them, and expressly classes all suicide as homicide. (*De Civ. Dei*, l. i. c. 19.)

Among the writings of later thinkers, the reasonings urged by Rousseau against suicide in the *Nouvelle Héloïse* are well known. Though there is little convincing in his logic, yet the side he takes is made to appear the generous and noble one; and in this case Rousseau must be owned to have done service to the cause of morality. Madame de Staël, in her *Essay on the Influence of the Passions*, advanced a sort of defence of suicide; in her later work (*Réflexions sur le Suicide*, published in 1810) she has enforced the more customary doctrine with much eloquence and feeling.

In discussions on the subject of proneness to suicide in particular classes or nations, it is impossible to disconnect it from that of insanity; because the miserable delusions of that disease constantly impel their victim to its commission. In societies, therefore, where insanity is most common, the number of suicides will be greatest. The tendency to deliberate suicide has been almost epidemic in many communities. Nor does it arise from similar causes, or in similar states of society. It prevails sometimes in effeminate communities, where there is little zest or excitement in life, with mean habits, little self-respect, and much apathy: thus, it is extremely common in China, even, it is said, among the lower classes, notwithstanding the proclamations, full of ethical saws, which the magistrates issue against its commission. Among people of minds thus disposed, the act is generally deliberate, and unconnected with insanity; so, again, where it results from a cold temperament, and a sarcastic and contemptuous view of life, which was the notion formerly entertained by foreigners of the English mania for suicide; a notion which probably had not much foundation in truth at any time. Sixty years ago, Mercier (*Tableau de Paris*, vol. iv.) thought that it prevailed less in England than France. At present the proportion is certainly reversed.

With respect to the causes of suicide, some curious results have been obtained by statisticians. [STATISTICS.] It appears from a classification of 134 suicides committed in ten years at Geneva (by M. Prevost, in vol. xv. of *Annales de Hygiène*), that the following causes produced them:—

Disease	34
Mental alienation	24
Pecuniary misfortunes	19
Domestic *chagrins*	15
Melancholy, cause unknown	13
Misconduct, drunkenness	10
Fear of punishment, remorse	6
Chagrins of love	7
Gambling and lotteries	4
Mysticism	2

Comparing these with other accounts, it

would seem that love produces at Paris $\frac{1}{26}$ of the suicides committed, at Geneva $\frac{1}{22}$, at Petersburg $\frac{1}{8}$, if Mr. Schön is to be believed; a singular contrast to the commonly supposed effects of climate. Domestic griefs at Paris (from 1794 to 1823), $\frac{1}{5}$; at Geneva the same. Misconduct at Paris $\frac{1}{23}$, at Geneva $\frac{1}{13}$, at Petersburg $\frac{1}{8}$. Gambling at Paris $\frac{1}{43}$, at Geneva $\frac{1}{14}$. Some of these results, in Paris and Geneva, are certainly remarkable for their correspondence. (See an essay of M. Brouc, in vol. xvi. of the *Annales de Hygiène*, already cited. The reader may consult also M. de Villeneuve Bargemont, *Econ. Politique Chrétienne.*)

If such official returns as we possess can be trusted, it would appear that suicide for about 20 years after 1817 was increasing but slowly in Paris, stationary in London; in the former city between 1 in 2,000 and 1 in 3,000, in the latter between 1 in 6,000 and 1 in 7,000.

The tables given below (from the Registrar-General's annual report) suggest that suicide is on the increase. The first gives an account of the five years ending with 1856; the second of seven years ending with 1864. By an oversight, it would seem, no statistics of suicide in England and Wales were given for the year 1857; for self-sought was not distinguished from accidental death in the returns of that year.

It appears that the number of suicides is understated, and we are informed that it should be raised by about a ninth part, if the coroner's returns to the Home Office be taken as the basis of an estimate. It is believed that a certain number of persons found drowned may be considered as unrecognised suicides. One of the most exhaustive and valuable works on this subject is the treatise, *Du Suicide*, of M. E. Lise (Paris, J. B. Baillière, 1856).

Deaths at different Ages returned as having occurred in England from Suicide in the Five Years 1852 *to* 1856.

	All ages	5	10	15	25	35	45	55	65	75	85	95 and upwards	Not stated
Males.													
1852 to 1856 .	3,886	..	19	348	547	726	910	778	410	127	9	..	12
Females.													
1852 to 1856 .	1,529	..	14	273	244	272	336	219	135	28	5	..	3
Average Annual Deaths of Males to* 1,000,000 *living at each age.													
1852 to 1856 .	85·1	..	3·8	40·1	80·0	138·4	240·0	1·1	295·6	252·4	136·2	..	..
Average Annual Deaths of Females to* 1,000,000 *living at each age.													
1852 to 1856 .	32·3	..	2·8	30·2	33·3	49·3	83·6	80·2	84·0	43·8	50·9	..	..

Deaths at different Ages returned as having occurred in England from Suicide in the Seven Years 1858 *to* 1864.

	All ages	5	10	15	25	35	45	55	65	75	85	95 and upwards
Males.												
1858 to 1864 . .	6,749	..	32	545	886	1,294	1,540	1,474	759	198	21	..
Females.												
1858 to 1864 . .	2,462	1	19	435	378	428	532	374	222	66	12	..
Average Annual Deaths of Males to* 1,000,000 *living at each Age.												
1858 to 1864 . .	98·4	..	4·3	42·6	90·7	166·7	249·1	362·3	374·5	266·1	238·4	..
Average Annual Deaths of Females to* 1,000,000 *living at each Age.												
1858 to 1864 . . .	34·1	·1	2·6	32·8	33·5	49·1	85·0	92·0	81·8	70·0	87·2	..

	Males	Females
Number of Suicides in London in the seven years 1858 to 1864	1,256	524

Suicide is ranked by the English law as a peculiar species of felony; and, like other felonies, cannot be committed by persons under the age of discretion, or insane. From very ancient times (see Bracton) the law imposed the forfeiture of personal property as a consequent of it; and a felo de se (as a wilful suicide is termed) forfeits all chattels, real and personal. But the offence was never attended with corruption of blood, or the forfeiture of lands of inheritance (for this was consequent on *attainder*, the result of *sentence*, and a dead man cannot be tried or sentenced), so that the will of a felo de se stands good as to realty. In order to vest these chattels in the crown, the fact of self-murder must be proved by an inquisition, which the coroner is the proper officer to hold. In addition, the law formerly required that a self-murderer should be buried in a highway, with a stake driven through his body. Now, by 4 Geo. IV. c. 52, his remains are to be privately buried at night in the churchyard. But the canon law (confirmed by the rubric in the Common Prayer Book) forbids the performance of Christian rites over them.

Suit. In Law, proceedings in the Court of Chancery, corresponding to an action at law, are so called.

Sulcate (Lat. sulcatus, *furrowed*). In Zoology, when a surface is deeply impressed with longitudinal parallel lines.

Sulphamide. A crystallised compound obtained by the action of anhydrous sulphuric acid on ammonia. A compound resulting from the action of ammonia upon chlorsulphuryl has also received the same name.

Sulphate of Baryta. [Baroselenite.]

Sulphates. Salts derived from sulphuric acid; green vitriol is a *sulphate* of the protoxide of iron. Glauber's salt is a *sulphate* of soda.

Sulphides, Sulphurets. Compounds of sulphur with electro-positive or inflammable bodies. The most common ores of copper and of lead are *sulphides* or *sulphurets* of those metals.

Sulphites. Salts of the sulphurous acid.

Sulphocyanic Acid. This acid was discovered in 1808 by Mr. Porrett, who ascertained it to be a compound of sulphur, carbon, hydrogen, and nitrogen; he called it *sulphuretted chyazic acid*, the term *chyazic* being composed of the initial letters of carbon, hydrogen, and azote. It is formed by distilling a strong solution of sulphocyanide of potassium with phosphoric acid, when sulphocyanic (or more properly *hydro-sulphocyanic*) acid passes over into the recipient, and phosphate of potassa remains in the retort. So obtained, it is a liquid of a slight pink hue, and smells somewhat like vinegar. The strongest solution has a specific gravity of 1·022: boils at 217°, and crystallises at 55° in six-sided prisms. It gives a characteristic deep red solution with persalts of iron; with a salt of copper it gives a white precipitate. It is composed of C_2NS_2H.

Sulphocyanide of potassium is obtained by mixing equal weights of powdered sulphur and ferrocyanide of potassium, and keeping them in fusion for half an hour in a flask; when cold, reduce the mass to powder, and digest it in water; filter the solution, and add a sufficiency of caustic potash solution to throw down the iron.

Sulphonaphthalic Acid. A compound derived from sulphuric acid and naphthalin.

Sulphovinic Acid. *Sulphethylic acid.* An acid formed by the action of sulphuric acid upon alcohol. It consists of a molecule of sulphuric acid in which an atom of hydrogen has been substituted by ethyl. Its formula is $S_2O_8(C_4H_5)H$.

Sulphur (Dutch solfer, Fr. soufre). *Brimstone.* A yellow brittle mineral found in various parts of the world, but most abundantly in volcanic regions. Europe is supplied with it chiefly from the south of Italy and Sicily, usually associated with sulphate of strontia or gypsum. It most commonly occurs massive; but it is sometimes met with crystallised in the form of an acute rhombic octahedron. Sulphur is principally employed in the arts for the manufacture of sulphuric acid; very little of the native mineral, however, is made use of for this purpose, the chief source of supply being iron pyrites or bisulphide of iron, which when calcined evolves its sulphur as sulphurous acid. Native sulphur is chiefly used for gunpowder-making and for sulphuring vines.

Small quantities of sulphur also occur in several animal and vegetable products, and are frequently recognised by the odour of sulphuretted hydrogen which they evolve during putrefaction. Sulphur is a non-conductor of electricity, insipid, and inodorous, unless rubbed or heated, when it evolves a sulphurous smell. Its specific gravity is 1·99. It melts at about 216°; and when heated to about 250° it becomes a limpid, amber-coloured liquid; if the heat be raised to about 450°, it again becomes viscid and deeper coloured; at 480° up to its boiling point it acquires rather more fluidity; at about 600° it rises rapidly in vapour, and in close vessels condenses in the form of a fine yellow powder, composed of crystalline grains: in this state it is called *flowers of sulphur*. It boils at 836°. The earthy and metallic impurities which, with a portion of sulphur, remain in the subliming vessel, were formerly called *sulphur vivum*. When sulphur in its viscid state of fusion is poured into water it becomes a ductile mass, which slowly hardens, and which is often used for taking impressions of seals and medals. When sulphur is in the form of vapour it is of a dense orange colour; its specific gravity in that state is about 6·6, and 100 cubic inches of it should therefore weigh about 206 grains.

Another form of sulphur, sometimes called *milk of sulphur* (lac sulphuris), is obtained by precipitating sulphur by muriatic acid from certain of its alkaline solutions. When sulphur

which has been melted is suffered to cool slowly, its interior often exhibits prismatic crystals, and very beautiful specimens of this artificial crystallisation of sulphur may be obtained by melting a few pounds of it in a crucible or ladle, and, when it is partially cooled, piercing the outer crust and inverting the vessel, so that the interior liquid part may run out; on breaking the mass when cold, the cavity will be found lined with prismatic crystals.

The results of the combustion of sulphur, its atomic weight (16), and several other details respecting its combinations and uses, are given under the heads of SULPHURETTED HYDROGEN, SULPHURIC ACID, and SULPHUROUS ACID.

Sulphur is insoluble in water; it dissolves in bisulphide of carbon, and is deposited in small crystals as the solution evaporates. It is also soluble in alcohol, if both substances be brought together in the state of vapour. It combines with chlorine, bromine, and iodine. Its native combinations with the metals form some of the most important ores. It is from the sulphides of lead and of copper that the commercial demands for these metals are almost exclusively supplied.

Sulphur is of great importance in the arts. It is used extensively in the manufacture of gunpowder, and in the formation of sulphuric acid, or oil of vitriol. It is also used in medicine.

Sulphur Salts. Chemists have applied this term to certain *double sulphides*. The sulphides of the most electro-positive metals have been termed *sulphur bases*, such as the protosulphides of potassium, sodium, barium, &c.; whilst the sulphides of arsenic, antimony, &c., the bisulphide of carbon, and sulphuretted hydrogen, have been called *sulphur acids*; and the compounds resulting from the union of a sulphide of the former with one of the latter class are *sulphur salts*.

Sulphuration. The process by which certain silk, cotton, and woollen goods are subjected to the fumes of burning sulphur, or sulphurous acid, for the purpose of decolouring or bleaching. The rooms or chambers in which the operation is conducted are often of considerable dimensions, and fitted with poles and frames on which the blankets, shawls, and similar articles may be suspended. The straw used in the manufacture of hats is similarly bleached or sulphured. [SULPHUROUS ACID.]

Sulphureous Springs. [SPRINGS.]

Sulphuretted Hydrogen. *Hydro-sulphuric acid.* A gaseous compound of one atom of sulphur = 16 + 1 atom of hydrogen = 1. The equivalent, therefore, of sulphuretted hydrogen is 17. This gas was first examined by Scheele in 1777. It may be obtained by acting upon sulphuret of antimony by muriatic acid, or upon protosulphuret of iron by diluted sulphuric acid, and is immediately recognised by its peculiar fœtid odour, which is so diffusible that a single cubic inch of it escaping into the atmosphere of a large room is soon everywhere perceptible. It is very injurious to respiration; 100 cubic inches weigh about 38 grains, its specific gravity compared with air being as 1,174 to 1,000, or, compared with hydrogen, as 17 to 1. It is liquefied by a pressure of 17 atmospheres at 50°. Water agitated with this gas takes up three times its own volume, and acquires a bitterish nauseous flavour with the odour which characterises the Harrogate and Aix-la-Chapelle waters, which derive their chief peculiarities from the presence of this gas. Sulphuretted hydrogen extinguishes flame; but is itself inflammable in contact with air, burning with a blue flame. When mixed with excess of oxygen and inflamed, it explodes, and the mixture is converted into sulphurous acid and water. One volume of the gas requires one volume and a half of oxygen for its entire combustion, and the results are water, and one volume of gaseous sulphurous acid. This gas is immediately decomposed by chlorine and by iodine, which, if not added in excess, throw down its sulphur and combine with its hydrogen. It is unequivocally recognised by its peculiar odour, and by its blackening the salts of lead. Sulphuretted hydrogen, diluted with 20,000 measures of pure hydrogen, sensibly blackens a piece of paper which has been dipped into a solution of acetate of lead: white lead is also immediately discoloured by it; hence the mischief which it does to white paint, and to pictures. The aqueous solution of sulphuretted hydrogen reddens litmus; and inasmuch as it combines with certain bases, it is properly considered as a weak acid.

Sulphuric Acid. *Oil of vitriol.* This most important acid was discovered by Basil Valentine, towards the end of the fifteenth century. It was formerly obtained by the distillation of green vitriol (sulphate of iron), and from its oily appearance it acquired the name, which it still bears, of *oil of vitriol*. In this country it is procured by burning seven or eight parts of sulphur, and at the same time decomposing in the same furnace one part of nitrate of soda or of potash with sulphuric acid. The sulphur is burnt in a furnace so contrived that a current of air carries the products of the combustion into a large leaden chamber, the bottom of which is covered to the depth of a few inches with water. The principal products of the combustion of the sulphur and of the decomposition of the nitre are sulphurous acid and peroxide of nitrogen; and these, together with atmospheric air and steam, which is admitted from several jets, form the contents of the chamber.

The sulphurous acid and peroxide of nitrogen, with a portion of water, combine to form a white crystalline substance, which, upon falling into the water of the chamber, is instantly decomposed. The peroxide of nitrogen imparts oxygen to the humid sulphurous acid, and so converts it into sulphuric acid; whilst the peroxide of nitrogen, having lost oxygen, reverts to the state of *nitric oxide*, which is given out into the air of the chamber, from which it

immediately again abstracts oxygen, and becoming peroxide of nitrogen, is again ready to acidify a new portion of sulphurous acid. The oxygen, therefore, is thus indirectly transferred to the sulphur, or to the sulphurous acid, from the atmosphere, through the medium of the attractive power of the nitric oxide for that element; and the circumstance that this process is repeated over and over again by the same portion of peroxide of nitrogen, accounts for the small quantity of nitre required in this curious process.

When the water in the chambers is rendered sufficiently acid, which is judged of by its specific gravity, it is drawn off into leaden boilers, where it is evaporated down to the density 1·76; after which, as it would then act upon the lead, it is transferred to platinum boilers supplied with still-heads, and is there brought to its proper degree of concentration by further distilling off a portion of the residuary water. This last process was formerly conducted, at great risk and inconvenience, in glass retorts: its present improvement shows a most important application of platinum, which is not acted upon by the boiling acid. Of late, sulphuric acid has been largely manufactured from the sulphur obtained by roasting common pyrites (sulphuret of iron); one of the objections to which is, that it almost always contains more or less arsenic, by which the resulting acid is therefore contaminated. The acid made from Sicilian sulphur is indeed not always free from this mischievous impurity.

Sulphuric acid is a limpid colourless fluid, of a specific gravity of 1·842. It boils at 640°; it freezes at −30°; but the temperature at which the diluted acid congeals is singularly modified by the quantity of water which it contains. When of the specific gravity of 1·78 (which may be regarded as a compound of one atom of dry acid and two of water), it freezes at 40°, and remains solid for a long time at several degrees above that point: if the density be either diminished or increased, a greater cold is required to congeal it.

It is acrid and caustic, and intensely acid in all its characters, even when largely diluted. Its attraction for bases is such that it separates or expels all other acids more or less perfectly from their combinations. Its affinity for water is such that it rapidly absorbs it from the atmosphere, and when mixed with water much heat is evolved: thus by suddenly mixing four parts of the acid and one of water at 60°, the temperature rises to 300°. Its attraction for water also causes the sudden liquefaction of snow; and if mixed with it in due proportion, an intense cold is the consequence. It acts energetically upon animal and vegetable substances, generally charring them, and often, as in the case of *sugar*, with singular rapidity.

This acid, as it usually occurs in commerce, under the name of *concentrated sulphuric acid*, is a compound of 1 atom of anhydrous acid and 1 of water. The anhydrous sulphuric acid (*sulphuric anhydride* of some writers) is constituted of 16 sulphur (1 atom) and 24 oxygen (3 atoms); its equivalent, therefore, is $16 + 24 = 40$: i. e. the composition of the acid as it exists in the *anhydrous sulphates*. The strongest liquid acid consists of 40 of the anhydrous acid (1 atom) and 9 water (one atom), and is therefore represented by the equivalent $40 + 9 = 49$. Sulphuric acid is, however, now generally considered to be a dibasic acid, and to have double the combining weight just given.

Sulphuric acid is an article much used in commerce; its purity and value are judged of by its specific gravity. Upon this subject Dr. Ure's tables may be consulted, as showing the quantity of real or *dry*, and of commercial acid, in diluted acid of all densities.

By the term *real*, *dry*, or *anhydrous sulphuric acid*, we mean that which exists in the sulphates, and which may be obtained in a separate state by distilling protosulphate of iron, or green vitriol, at a high temperature: there supervenes a dense brownish liquid, which emits vapour when exposed to air, and has hence been termed *fuming sulphuric acid*. On putting this into a retort to which a receiver surrounded by ice or snow is carefully adapted, and heating it gently, a vapour passes over, which condenses into a white crystalline solid; this, which is *anhydrous* or *glacial* sulphuric acid, liquefies at about 70°, and evaporates at about 112°. Yet, when combined with such portion of water as constitutes the above described liquid acid, it is one of the most fixed of fluids. It hisses when dropped into water in consequence of the great heat evolved.

The ready test of sulphuric acid is a soluble salt of baryta; the solution of chloride of barium is generally used, which, when dropped into any solution of free or combined sulphuric acid, announces its presence by a white cloud or precipitate of *sulphate of baryta*, which is insoluble in nitric acid. In the same way sulphuric acid, and the sulphates, are tests of baryta.

Sulphuric Ether. [ETHER.]

Sulphurous Acid. This acid consists of 32 sulphur + 32 oxygen; its equivalent being 64. It is obtained by heating sulphuric acid in contact with certain metals, which abstract an atom of its oxygen; such, for instance, as silver or mercury. It is also formed by burning sulphur in oxygen gas. One volume of water takes up about 40 volumes of sulphurous acid gas; so that it requires to be collected and preserved over mercury, or in dry stoppered phials. It has the well-known suffocating odour of burning sulphur, and is possessed of considerable bleaching powers; so that the fumes of burning sulphur are often used to whiten straw, and certain silk and cotton goods; and when certain flowers, such as violets, dahlias, &c., are exposed to such fumes, or to sulphurous acid, their colours are mostly destroyed. Upon other colouring matters it has little effect. 100 cubic inches of sulphurous acid gas weigh between 67 and 68 grains; its specific gravity compared with

atmospheric air being 2·22. It extinguishes flame, and kills animals. When subjected to the pressure of about two atmospheres, or when cooled down to 6°, it assumes a liquid form; and in this state it evaporates with such rapidity at common temperatures as to produce a most intense degree of cold, so that by its aid chlorine may be liquefied and mercury frozen. It combines with bases, and produces a class of salts called *sulphites*; they are characterised by emitting sulphurous acid when acted upon by sulphuric acid, and by becoming converted into sulphates by oxidising agents.

Sultan (an Arabic word). The title of various Mohammedan princes besides the Ottoman emperor or grand sultan, to whom it is commonly given by Europeans, but whose peculiar title is Padishah. The princes of the deposed family of the khan of the Crim Tartars are also styled *sultan*: as is also the pasha of Egypt in that country, although not by the court of Constantinople.

Sumach (Ger. and Fr.). The popular name of the woody plants which form the botanical genus RHUS. The same term is also applied to the powder of the leaves, peduncles, and young branches of the *Rhus Coriaria* and *Rhus Cotinus*, shrubs which grow in Hungary, the Banat, and the Illyrian provinces. That derived from both kinds contains tannin, with a little yellow colouring matter, and is a good deal employed for tanning light-coloured leathers; but the first is of the best quality. With mordants, it dyes nearly the same colours as galls. In calico-printing, sumach affords, with a mordant of tin, a yellow colour; with acetate of iron, weak or strong, a grey or black; and with sulphate of zinc, a brownish yellow. A decoction of sumach reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale yellow flocks with alum; dark blue flocks with red sulphate of iron, with an abundant precipitate. In the south of France, the twigs and leaves of the *Coriaria myrtifolia* are used for dyeing under the name of *rédoul* or *rodou*. The imports for home consumption amount to about 200,000 cwt. a year.

Summation (Lat. summus, *highest*). In Mathematics, the operation of adding or finding the sum of several quantities. When the quantities to be added form a series, the sum of any number of terms is indicated by prefixing the *sign of summation* Σ to the general term; the *limits* of the sum are also sometimes indicated; thus $\sum_{i=1}^{i=n} a_i$ denotes the sum $a_1 + a_2 + \ldots + a_n$. Instances of summation will be found under INTEGRATION; DIFFERENCES, CALCULUS OF; and PROGRESSION.

Summer (A.-Sax. sumer, Ger. sommer). One of the four seasons of the year. The summer season, for the northern hemisphere, begins when the sun reaches the tropic of Cancer, and ends at the following equinox.

SUMMER (Fr. sommier; quasi trabs summaria, *an upper beam*). In Architecture, any large piece of timber supported on two strong piers or posts, and serving as a lintel to a door, window, &c. [BRESSUMMER.]

Summons, Writ of. In Law. All actions in the superior courts of common law are now commenced by a writ of summons in a prescribed form, viz. by a writ issued in the queen's name out of the court in which the action is brought, directed to the intended defendant, describing him as of the county and place where he is supposed to reside or be, and commanding him to cause an *appearance* to be entered for him in that court, in an action at the suit of the plaintiff, within eight days after the writ shall be served upon him (the defendant). The amount of the debt claimed, if the action be to recover a debt, with other requisite particulars, must be endorsed on the writ. The writ remains in force for six calendar months, but may be renewed as often as there may be occasion. (3 Steph. *Comm.*)

Sumptuary Laws (Lat. sumptus, *expense*). Laws intended to restrain the expenditure of citizens. Sumptuary laws abounded in ancient legislation. Thus, among the Romans, the Lex Orchia limited the number of guests at a feast; the Lex Fannia restricted the cost of an ordinary entertainment to ten *asses*, and so forth. They were also common in the earlier legislation of this country.

All sumptuary laws intended to 'check excess in apparel and prohibit costly clothes' (passed chiefly in the reigns of Edward III., Edward IV., and Henry VIII.) were repealed by 1 Jas. I. c. 25. But one statute prohibiting excess in diet, 10 Edw. III. c. 3, which enacted that no one should be served at dinner or supper with more than two courses, except on certain specified holidays, and which had long fallen into desuetude, was expressly repealed by 19 & 20 Vict. c. 64.

The most successful of such attempts to regulate prices have been those which fixed the wages of labour. It was quite in accordance with this disposition to interfere with supply and demand, that enactments were made with a view to control expenditure; and, therefore, towards the conclusion of the fourteenth century, and subsequently, a variety of statutes were passed prohibiting certain kinds of dress, or at least limiting them to certain ranks in society, and defining, often with very great minuteness, what should be the customary habits and food of other ranks.

There will always be a question as to the propriety of an administration attempting to prohibit acts which are said not to be mala per se, or indeed any acts which have no directly evil effect on the rights of others. But of these prohibitions, none is more certain to be evaded than sumptuary laws. Individuals will be slow to recognise the right of government in such action, and when a license is given to some persons which is not accorded to others, every person is impelled to challenge and traverse the law. In a community like the Spartan, where abstinence was enforced on all alike, it was impossible to maintain the law. In our own

country, during the existence of the Gin Act, intemperance was never so common; and it is averred that even where a popular legislature, as in the state of Maine, has prohibited the sale of intoxicating liquors, as much or nearly as much is sold secretly as before was sold openly. But the case is still stronger when the law is intended to affect some persons and to give license to others.

It may be further remarked, that the promulgation of sumptuary laws depends necessarily on the ideas entertained of the province of government. The modern theory, which tends to confine the action of government more and more to the protection of person and property, leaves no room for any such legislation [Liberty]; and this tendency acquires naturally a greater force in large kingdoms than in small states. In the latter, the idea of the state or society is sure to override indefinitely the idea of the individual; and thus a sumptuary legislation is as natural to the ancient Roman republic as to that of Sparta. In the former, the citizen, although he retained his own home and to a certain extent the privacy of his house, was regarded as wholly subordinate to the state, which could interfere with him at its will; in the latter, the citizen can scarcely be considered as a private person at all. [Syssitia.] According to the Aristotelian theory of politics, sumptuary laws formed an indispensable part of every civil code. If the state was bound, as Aristotle maintained, to see to and insure the mental and moral welfare of all its citizens, it was bound to prescribe not merely the books which they were to read, but the dishes which they should eat, and the clothes which they must wear.

In their practical working, sumptuary laws in more modern times have been used as instruments for keeping up the distinctions of classes, and thus as a means for upholding the power and influence of an aristocracy. The theories of religion disseminated by the mediæval clergy united with these political prejudices, as Hallam has remarked (*Middle Ages*, ch. ix. part ii.), 'to render all increase of general comforts odious under the name of luxury; but while the kings of France and England multiplied laws about the food and dress of their subjects, they were themselves more egregious spendthrifts than any others in their dominions, and contributed far more by their love of pageantry to excite a taste for dissipation in their people than by their ordinances to repress it.'

Sun (the Sanscrit root is sur, *to glitter*, Gr. ἥλιος, Lat. sol, Ger. sonne). In Astronomy, the central body of our system, about which all the planets and comets revolve, and by which their motions are regulated and controlled. The sun is the source of light and heat, and therefore the primary cause of all the motions and changes effected on the surface of the earth by those great agents of nature.

Apparent Magnitude of the Sun.—The sun presents to the naked eye the appearance of a luminous circular disc, subtending an angle of rather more than half a degree. But on measuring accurately the diameter of the disc, it is found to be not always the same, but subject to an annual variation. In fact, as the earth describes an ellipse, of which the sun occupies one of the foci, its distance from the sun is constantly changing, and the variation of the sun's apparent diameter is a necessary consequence of the change of distance. When the earth is in its perihelion, or point of its orbit nearest to the sun, the sun's apparent diameter is 32′ 36·41″, and when the earth is at its aphelion, or the most distant point, the apparent diameter is 32′ 3·64″.

The accompanying table of elements gives the latest values obtained.

	Old Value	New Value
Equatorial horizontal parallax	8·5776″	8·915″
Mean distance from the Earth	95,274,000	91,678,000
Time of rotation	Variable with the latitude. The rotation in 24 hours of mean solar time is expressed by the formula, 865′ ± 165′ sin $\frac{1}{2}$ *l*.	
Diameter in miles	888,646	853,380
Inclination of axis to plane of ecliptic	82° 45	for 1850
Longitude of node	73 40	for 1850
Mass (Earth's as 1 =)	354,936	316,047
Density (Earth's as 1 =)	0·250	
Volume (Earth's as 1 =)	1,415,225	1,260,160
Force of gravity at Equator (Earth's as 1 =)	28·7	27·6
Apparent diameter as seen from the Earth, maximum		32′ 36·41″
Apparent diameter as seen from the Earth, minimum		32′ 3·64″

Distance of the Sun.—The sun's true distance is found from his horizontal parallax. This is so small a quantity that practically it is not possible to determine it in the usual way by observations made on opposite sides of the earth; but the astronomical phenomena of the transits of the planet Venus over the sun's disc afford the means of determining it with the utmost precision. From the transits which occurred in the last century, a parallax was obtained of 8·5776 (shown as the old value in the above table); i.e. if an observer could be placed at the centre of the sun, the earth's semidiameter would be seen by him under an angle of 8·6″. From this it followed that the mean distance of the sun from the earth must be at least equal to 24,047 times the earth's radius; and as the radius of the earth is nearly 4,000 miles, it follows that the sun's true distance, calculated from that parallax, must be about 95,000,000 miles.

As mentioned, however, in the article Planet, recent investigations have resulted in a smaller value of this distance. Observations of the planet Mars at opposition, investigations into the motions of the moon and masses of the planets, and the velocity of light, all agree in a remarkable manner in showing that some 3,000,000 miles must be deducted from the old value.

In order to obtain a more distinct idea of this enormous distance, we may compute the time in which it would be passed by some of the swiftest motions with which we are acquainted. A cannon ball, fired with a charge of 8 lbs. of gunpowder, is projected with a velocity of about 1,600 feet in a second. Supposing it were to move towards the sun with a uniform velocity, it would require nearly ten years to reach its surface. Light itself, which travels with the astonishing velocity of 192,500 miles in a second, only reaches the earth eight minutes and eighteen seconds after leaving the sun's surface.

The distance and apparent diameter of the sun being known, it is easy to compute its real dimensions. The new value of the diameter is 853,380 miles. The mean distance of the moon being rather less than 60 times the earth's radius, if the sun's centre were placed at the centre of the earth, its surface would be at twice the distance of the moon's orbit; and the volume of a sphere whose radius is equal to that of the moon's orbit would be only an eighth part of the volume of the sun. The sun's volume is 500 times greater than the volumes of all the planets taken together.

Mass and Density of the Sun.—The magnitude and distance of the sun are determined by direct observation; his mass as compared with that of the earth is deduced from the law of universal gravitation.

We can determine on the earth at what rate a body falls to the earth. The earth's orbit tells us at what rate the earth itself falls to the sun. Experiment tells us that, on the surface of our globe, a heavy body traverses sixteen feet during the first second of its fall; and as, according to Newton's theory, the attraction of a sphere acts on external bodies, as if the entire mass of the sphere were concentrated at its centre, we must consider the heavy body falling on the surface of the terrestrial globe, as situated at a distance from the centre of attraction equal to the radius of the earth. The mass of the earth, then, acting on a body situated at a distance of 4,000 miles, causes it to fall 16 feet in one second. On the other hand, the earth itself gravitates towards the sun; the orbit which it thus describes in a year shows how much it falls towards the sun during the first second of fall. The distance is found to be ·0099 feet. We must now reduce this measure of the attractive energy of the sun to what it would be at a distance from its centre equal to 4,000 miles, or to the terrestrial radius, a distance 23,984 times smaller than the sun's distance according to the old value.

The law of gravitation indicates that the preceding number must be multiplied by the square of 23,984 feet. Doing this, we find that the mass of the sun, acting on a body situated at a distance of 4,000 miles from its centre, causes it to travel, in the first second, 5,708,763 feet, or 1,075 miles. We can now compare the mass of the sun with that of the earth since we know the actions of these two masses, on a body situated at the same distance from their centres; and it is clear, that the mass of the sun is by so much greater than that of the earth, as the number 5,708,763 is greater than 16. Dividing, we find in round numbers 355,000. We must have, then, 355,000 globes of the same weight as ours to balance the sun.

The density of a body is directly as its mass, and inversely as its volume. If, therefore, we call the density of the earth 1, the ratio of the density of the sun to that of the earth will be, to take the new value, as $\frac{316047}{1260160}$ to 1, or as 0·25 nearly to 1, or as 0·254, whence the sun's density is about one-fourth of that of the earth.

In order to compare the force of solar gravity at the sun's surface with that of terrestrial gravity at the earth's surface, we must again recollect that the attraction of a body on an exterior point is directly as the mass of the attracting body, and inversely as the square of the distance of the point from its centre. Hence, a body, which at the earth's surface weighs one pound, would weigh 27·6 pounds if carried to the surface of the sun. An ordinary man would not only be unable to sustain his own weight on the sun, but would be literally crushed under the load.

Rotation of the Sun.—The sun, when viewed through the telescope, is generally observed to have on its surface a number of dark patches or *spots*, which being observed from day to day are found not to remain in the same place, but to move across the surface, without changing their relative positions to any great extent. These phenomena are accounted for by supposing the sun to have a rotatory motion about an axis from west to east. The early observations of Delambre, Bianchi, and Laugier, were by no means concordant, but an average rotation of 25 days was obtained. The recent discovery that the time of rotation of the photosphere, or the external bright cloudy envelope which we see, varies with the latitude of the part observed, is due to Mr. Carrington.

Spots on the Sun.—Numerous hypotheses have been formed respecting the solar spots. They began to attract attention soon after the discovery of the telescope. Scheiner supposed them to be planets revolving at no great distance from the sun's surface. Galileo and Hevelius conceived them to be a sort of *scoriæ* or *scum* formed at the surface of the sun, and floating in an ocean of liquid matter. Lahire supposed them to be protuberant parts of solid, opaque, and irregular masses, floating in the liquid matter of the sun. Dr. Wilson, of Glasgow, accounted for the spots by supposing the sun to consist of a dark nucleus, covered to a certain depth by luminous matter, through which cavities or gulfs are made by volcanic or other actions, thus permitting the dark nucleus to be seen. Lalande suggested that the spots or opaque bodies may be merely the summits of mountains, usually covered by the igneous fluid, but which, by the flux and reflux of the fluid, sometimes protrude

beyond its surface, and thus become visible. Sir William Herschel, following Dr. Wilson, considered the luminous strata of the atmosphere to be sustained far above the level of the solid body by a transparent elastic medium, carrying on its upper surface (or rather at some considerably lower level within its depth) a cloudy stratum, which, being strongly illuminated from above, reflects a considerable portion of the light to our eyes, and forms a penumbra, while the solid body shaded by the clouds reflects none. The temporary removal of both the strata, but more of the upper than the lower, is, in his opinion, effected by powerful upward currents of the atmosphere, arising, perhaps, from spiracles in the body, or from local agitations. (Sir J. Herschel's *Outlines of Astronomy*, p. 229.) The most recent ideas on the subject, derived from observation and considerations of the sun's physical constitution, are opposed to all these hypotheses, as it is now accepted on all hands that the sun's light and heat are really due to a state of incandescence of a body surrounded by an absorbing atmosphere. Almost all the phenomena presented both by sun-spots, faculæ, and the general surface, are satisfied by supposing the photosphere to be built up of clouds. If the margin of a sun-spot be observed, the bright granules which, as pointed out by Sir William Herschel, cover the whole surface of the sun, are observed to change their generally circular or nearly circular shape for a more elongated one as they descend down the slope of the penumbra, and on rarer occasions still they are seen to float over the region occupied by the umbra and melt in their passage. Hence the spots are supposed to be openings in the cloudy stratum, and the question arises, What is the dark portion then rendered visible? M. Faye explains it by looking upon the photosphere as a shell enveloping a nebula. Mr. Balfour Stewart and others ascribe it to a reduction of temperature caused by a downward current of cold air.

The solar spots are exceedingly irregular in shape; and, when watched attentively for some time, they are observed to enlarge and contract, and to change perpetually their form and outline. Frequently they disappear before they approach the edge of the disc, and others break out suddenly in places where none were seen before. Sometimes a spot has been seen to break up into several parts, and the fragments to separate from each other, as if acted upon by an explosive force. The *nucleus* of a spot is perfectly black, and sharply defined; and is surrounded by an *umbra*, or border of a fainter shade; this, again, is surrounded by a penumbra. In the neighbourhood of large spots, or in places where they are numerous, bright streaks, or portions more luminous than the general surface of the sun, called *faculæ*, are frequently seen. Among these faculæ spots are often observed to break out; and when this does not happen, they are generally succeeded by spots, larger in proportion to the brightness of the antecedent faculæ. The region of the spots is generally confined to the parts of the sun within about 30° of the equator, beyond which they are rarely seen.

The magnitude of the spots, and the scale on which their movements are performed, are not the least remarkable circumstances connected with the phenomena. At the distance of the sun, a line which subtends an angle of one second is equal to about 460 miles, and a circle of that diameter has an area of about 166,000 miles; and this is the smallest space which can be distinctly discerned on the sun's disc. But a spot was observed by Mayer having a diameter equal to $\frac{1}{20}$ of the diameter of the sun, or upwards of 96″, and consequently (supposing it to be circular) covering an area of 1,520 millions of square miles—upwards of 30 times the whole surface of the earth.

Physical Constitution of the Sun.—Our most recent conception of the physical constitution of the sun is derived from a discovery of Kirchhoff's, which shows that it is the solid or liquid nucleus of the sun, and not the atmosphere, which is the principal source of light, and that the light so emitted has certain colours filtered out during its passage through the sun's atmosphere. The same philosopher has also shown the existence of the metals sodium, potassium, magnesium, iron, chromium, and nickel in the atmosphere of the sun. For further information respecting these discoveries, see SPECTRUM ANALYSIS.

Considering the enormous and incessant emanation of light and heat from the sun, the question has often arisen whether the volume of the sun undergoes any diminution. If the high temperature is kept up by friction or by the precipitation of meteoric matter into the sun, as first suggested by Mayer, no loss of volume would be sustained; but if the heat and light are produced merely by the cooling of the body of the sun, a diminution of volume would appear to be a necessary consequence. Observation, however, can afford us no information on this head; for, supposing an actual diminution to be going on at such a rate as to lessen the diameter by two feet in 24 hours (which, having regard to the sun's magnitude, may be considered as enormous), 3,000 years would elapse before the diminution of the apparent diameter would amount to a single second. Buffon supposed the sun to be an immense furnace, alimented by comets precipitating themselves into it from time to time.

Atmosphere of the Sun.—The existence of a solar atmosphere was inferred by Bouguer from a comparison of the intensity of radiation at different points of the disc. By reason of the globular figure of the sun, a much larger portion of the surface towards the border is comprehended under a given visual angle than at the centre; and, as every point of the surface must be supposed to radiate equally in all directions, it follows that the intensity of light near the border should be greater than at the centre, in proportion to the greater extent of surface

comprised under the same angle. Bouguer's observations, however, led him to infer that the light from the centre of the disc had a greater intensity than that which proceeded from the borders, a circumstance which would be explained on the supposition of its being absorbed in a greater proportion by having to traverse a greater extent of atmosphere. These observations have been recently confirmed by Roscoe, who has found that the photographic power of the sun's disc diminishes towards the edge. The existence of a solar atmosphere is also indicated by the ring of light and the singular red protuberances seen in solar eclipses, and especially in those of 1851 and 1861.

Sun's Position and Proper Motion in the Heavens.—The discoveries in sidereal astronomy which have been made in modern times, all tend to establish the hypothesis of a similarity of condition and a community of nature between the sun and the fixed stars. The prevalence of gravitation among these remote bodies, following the law observed in the solar system, is no longer a matter of speculation; the proof being afforded by the elliptic orbits described by so many of the double stars about their common centre of gravity. With respect to the place which the sun occupies in the heavens, we have, says Sir J. Herschel (*Mem. Royal Astron. Society*, vol. xi.), almost ocular evidence that our system is eccentrically situated within the region bounded by the *milky way*, and nearer to its southern than to its northern portion. It was also an opinion of Sir William Herschel, now confirmed beyond contradiction, that the sun, like many of the fixed stars, has a proper motion in space, in consequence of which it is at present advancing towards a point of the heavens within the constellation *Hercules*. Yet, though the *fact* that the sun has a proper motion in space may be regarded as certain, many centuries of observation may be required to enable astronomers to detect its laws, or even to arrive at any definite conclusions respecting the remote centre about which it is performed. An extension of Kirchhoff's discovery before mentioned has taught us that the physical constitution of the sun and stars are identical in the main, though the components of the nuclei and atmospheres may vary within certain limits. (Sir J. Herschel's *Astronomy*; Lalande, tom. iii.; Biot, *Astronomie Physique*; Laplace, *Système du Monde*; Delambre, *Astronomie*; Argelander, Struve, and Galloway, *On the Proper Motion of the Solar System*; Main, 'On the Proper Motions of the Stars,' in *Greenwich Catalogue*, &c.; *The Heavens*.) [STARS.]

Sun Opal. A name for Fire Opal, or for that variety of Opal which displays bright yellow and hyacinth-red reflections. It is found at Zimapan in Mexico; also in Cornwall, near St. Just, and at Huel Spinster and Rosewarne Mine.

Sun Worship. The evidence of language, as well as that of mythology, tends to show the general, if not the universal, existence of sun worship among the various tribes of men in the earliest ages. On the mental process which may have led to such a worship, something has been said in the articles LANGUAGE, MONOTHEISM, MYTHOLOGY, and POLYTHEISM. The worship naturally assumed different forms according to the peculiar tastes and tempers of the several nations; but the leading idea, which impressed itself especially on the Oriental mind, was that of the generative force of nature, as proceeding from the sun, and thus their worship of the sun was intimately connected with that of the LINGA, or PHALLUS, and YONI, answering to the Ashera and altar of Baal among the Jews, Phœnicians, and other Semitic peoples. This element was represented in the West chiefly in the MYSTERIES, and in the Phallic processions of Dionysus, &c. But the tendency of the Greek mind to invest with a human form the being who was supposed to direct each force in nature as distinguished from the force itself, brought the personal Apollo, or Dionysus, or Athena into a prominence which placed the worship of generative emblems more and more in the background, and invested it with an obscure and repulsive character; and thus to the Greek, Helios, the sun, became a secondary to Phœbus, the light-giver, standing to him in the relation of Nereus to Poseidon, or of Nephelê to Hera. In the *Odyssey*, Helios still has his sacred cattle in the Thrinakian land; but the legend is interesting chiefly as throwing light on the mythical phrases which seemed to have furnished a basis for many, if not most, of the incidents both of the *Odyssey* and the *Iliad*.

Sunday. The first day of the week, consecrated to the sun in heathen times. (Sir G. C. Lewis, *Astronomy of the Ancients*, p. 304 &c.) The solemnisation of this day dates from the earliest age of the Christian church, in memory of the death of Christ, and of the descent of the Holy Ghost. The Jewish Christians retained at the same time their Sabbath, the last day of the week; but this practice became obsolete early, at least in the Western church. The Sunday does not appear to have been strictly observed as a day of cessation from labour before the reign of Constantine. By the decree of that emperor (A.D. 321) public business and military exercises were suspended. The council of Laodicea (A.D. 360) forbade labour in general terms: and the laws of Theodosius (circ. A.D. 420) sanctioned this interdiction by civil penalties. [SABBATH.]

Sunday Letter. [DOMINICAL LETTER.]

Sunflower. [HELIANTHUS.]

Sunniah. The name assumed by the Mohammedans, as followers of the tradition or orthodox, in opposition to the Shiah sect, or the followers of Ali, who maintained that although Moawyiah, the first of the Ommiad dynasty of caliphs, had, by the forced abdication and murder of Hassan, possessed himself of the temporal power, yet the spiritual supre-

macy was inalienable from the direct descendants of the prophet. The followers of Ali have always been numerous; and the Persians, probably as much from national antipathies as from religious conviction, continue to assert the rights of the house of Ali. (Ockley's *History of the Saracens*.)

Sunstone. A resplendent variety of Felspar (Adularia) of a very pale yellowish colour; found in Siberia, Norway, and elsewhere. The play of colour which it exhibits arises from minute lamellar crystals of oxide of iron (Göthite) which are embedded in it.

Suovetaurilia (Lat. from sus, *a swine*; ovis, *a sheep*; and taurus, *a bull*). In Roman History, a quinquennial sacrifice, which consisted of the immolation of a sow, a sheep, and a bull; hence the name. [LUSTRATION.]

Supercargo. The person in a merchant ship appointed to superintend all the commercial transactions of the voyage.

Superdominant (Lat. super, *above*, and dominans, *governing*). In Music. In the descending scale, the sixth of the key.

Supererogation, Works of (Lat. supererogo, *to pay over and above*). In Theology, the belief that men may acquire merit in the eyes of God by good works beyond what are necessary for salvation. This notion is said by Protestants to have been first known about the twelfth or thirteenth century, and to have been founded upon what Roman Catholic theologians term *counsels of perfection*; i.e. rules which do not bind under the penalty of sin, but are useful only in carrying men to a higher degree of perfection than is requisite for ordinary Christians.

Superficial Measure. The measure of surfaces or areas; also called *square measure*. [MEASURE.]

Superficies (Lat.). A surface. The *superficial area* of a body is the quantity of surface which it possesses.

Superheated Steam. Steam to which an additional quantity of heat has been imparted subsequently to its generation, its volume being thus increased according to the law which governs the expansion of dry air by heat. The benefit of working steam at a high temperature is made apparent by the principles of thermo-dynamics, and in modern marine boilers the steam is very generally superheated by the waste heat of the smoke. Much superheating, however, occasions internal corrosion of the steam chest and of the engine, and also dries up the lubricating tallow of the piston and stuffing boxes, and burns out the hemp packing. In practice it is found that the steam should not be heated to a higher temperature than 315° Fahr.

Superior (Lat.). In Scottish Law, a superior is one who has made an original grant of heritable property with reservation of rent and service. The grantee is termed *vassal*: the interest of the grantor is *dominium directum*, that of the grantee *dominium utile*; or, the former *superiority*, the latter *property*. The reunion of these two rights in the same person is termed *consolidation*.

Superior Slope. In Fortification, the slope of the parapet outwards from the crest.

Superiors. In Printing, small letters or figures cast at the tops of the shank of types, thus (^{23}). They are generally used for references to marginal or foot notes, and in mathematical works.

Superlative (Lat. superlativus). In Grammar, the name vulgarly given to the so-called third degree in comparison, formed in the Teutonic languages by the additional syllable *est*.

Supernatural (Lat. super, *over*, and natura, *nature*). In the conflict of definitions propounded on this subject all that can be attempted in the present article is to give a brief sketch of the positions maintained by antagonistic thinkers.

These may be divided in the main into two classes: (1) those who hold that events have taken place in the world's history which cannot be referred to any law, and which, being displays of arbitrary power, and in this sense beyond nature, i.e. removed out of the ordinary chain of cause and effect, must be termed *absolute* miracles; and (2) those who maintain that all such events have been brought about in accordance with some further and higher laws which we have not yet been able to discover, and which, as having thus an exceptional and incomprehensible character, may be termed *relative* miracles.

The former position is maintained by Mr. Mozley (*Bampton Lectures*, 1865), more clearly, perhaps, than by any other writer of the present day. According to his definition, a miracle is a visible suspension of the order of nature for a providential purpose, serving as an evidence of revelation. Hence the coincidence of the miracle with the alleged Divine communication becomes an indispensable condition. No ordinary event could have this coincidence, inasmuch as it would be explained by its own place in nature. Hence it follows, that if a complete physical solution could be given of a whole miracle, 'it would cease from that moment to perform its functions of evidence; apparent evidence to those who had made the mistake, it could be none to us who had corrected it.' The evidential theory, thus adopted by Mr. Mozley, is regarded by others, who agree with him in many of his conclusions, as placing 'the supernatural in a light which makes it utterly incredible.' (*Christian Remembrancer*, October 1866.) Such writers maintain their position by asserting that the imparting of a revelation is not the sole or perhaps the chief end of God's dealings with man as set forth in the Old and New Testaments, and hat miracles belong to an order of events not more lying beyond the range of human experience than the facts of inductive science. According to this theory, miracles form 'that class of facts or phenomena which arise out of the relation in which man stands to God;' hence it follows that 'miracles at

least as great as those of Christ are day by day being transacted,' and that 'every time we kneel at the altar, we are bound to believe in a miracle second only to the Incarnation.' The miracles of Christ were 'the result of the hypostatic union,' their end being 'the accomplishment of the work of redemption.' These theological arguments, which will be put aside by those who think otherwise on the subject of the sacraments, or who put a different meaning on the term *Incarnation*, lead to the conclusion that the personal relation of man to God, 'if it is real, must be miraculous,' and that they who deny miracles must first 'deny a personal existence to man.' Hence, although 'great miracles like those of Christ no longer take place, because the gift residing in Christ is no longer in the world,' there still remain gifts of the Spirit, the same in kind. Far, then, from being past and exceptional acts on the part of God, miracles 'are part of a vast system now going on.'

This argument must be indefinitely affected by the definitions given of natural and mental action, and must indeed depend on the establishment of a distinction between the two; while it is further obvious that, although miracles as a class may come within the range of human experience, the several narratives of miracle must still, or rather on that very account, be subjected to a criticism based on the canons of historical credibility.

But more generally, the hypothesis accepted by recent writers is that of relative miracle. Thus Dr. M'Cosh (*The Supernatural in Relation to the Natural*) confines the word *miracle* 'to those events which were wrought in our world as a sign or proof of God's making a supernatural interposition or a revelation to man.' This definition, which, however, leaves the word *supernatural* undefined, seems to involve as the two conditions essential to a miracle, that they should be wrought by a Divine Power for a Divine purpose, and be of a nature such as could not be wrought by merely human contrivance. To this it has been replied, that the definition excludes from the class of miracles all those which are mentioned in the Bible as having been wrought for an evil purpose, and more especially those against which Moses is represented as warning the Israelites, if wrought by persons who invite them to the worship of false gods. It has been further argued, that, according to Dr. M'Cosh's definition, a miracle is only a superhuman work, and that this is not the sense in which anyone can have any difficulty in believing it, inasmuch as 'the powers and works of nature are all superhuman, more than man can account for in their origin, more than he can resist in their energy, more than he can understand in their effects.' But to this acceptation of the word Mr. Mansel (*Essay on Miracles*) seems to confine himself when he asserts that 'a superhuman authority needs to be substantiated by superhuman evidence, *and what is superhuman is miraculous*.' On this it has been remarked by the writer of an essay on 'The Supernatural' (*Edinburgh Review*, Oct. 1862), that Mr. Mansel's definition does not necessarily involve the idea of a violation of the laws of nature. 'It does not involve the idea of the exercise of will apart from the use of means; it does not involve, therefore, that idea which appears to many so difficult of conception. It simply supposes, without any attempt to fathom the relation in which God stands to His own laws, that out of His infinite knowledge of these laws, or of His infinite power of making them the instruments of His will, He may and He does use them for extraordinary indications of His presence.'

On the other hand, it has been urged that, whether this theory, which seems to make all miracle relative, be true in fact or not, it is one which was unknown to the writers of the Old Testament and the New, and is in opposition to all that they have said or related on the subject; that until there was some conception of an order of nature there could be no idea of miracle as a violation of that order; that for the Jewish and the early Christian writers a miracle was an event following no law, violating no order, but simply attesting the arbitrary action of a Being who could act in various ways at various times or in different places; that if they could have been brought to regard miracles simply as works beyond the reach of merely *human* powers, wrought by higher forces in accordance with existing but unknown laws, they would have ceased to see in miracles any value or to derive from them any consolation; that for them they were valuable and impressive, as being arbitrary and capricious combinations, which might break in upon a course of events of an ordinary character, but which might be so multiplied (as in the *Arabian Nights* fiction) as to become the rule rather than the exception. A confirmation of this view is found, it is said, in the tone of thought which characterised the Homeric age. In the words of Mr. Grote, if the old Greek 'could have been supplied with as perfect and philosophical a history of his own real past time, as we are now enabled to furnish with regard to the last century of England or France, faithfully recording all the successive events, and accounting for them by known positive laws, but introducing no special interventions of Zeus and Apollo, such a history would have appeared to him not merely unholy and unimpressive, but destitute of all plausibility or title to credence. It would have provoked in him the same feeling of incredulous aversion, as a description of the sun in a modern book on scientific astronomy.' (*History of Greece*, part i. ch. xvi.)

Apart from this idea of arbitrary action interfering in a world at no time and in no place governed by fixed and unvarying laws, miracles, it is said, must assume a merely relative character. Thus, the writer on

'The Supernatural,' already referred to, states that 'the reign of law in nature is, so far as we can observe it, universal;' and hence he rejects that idea of miracle which regards such alleged events as 'at variance with natural laws, above it, or in violation of it.' Hence, he adds, 'it would appear that to a man thoroughly possessed of the idea of natural law as universal, nothing ever could be admitted as supernatural, because on seeing any fact, however new, marvellous, or incomprehensible, he might escape into the conclusion that it was the result of some natural law of which he had before been ignorant.' This is the conclusion not 'of pride, but of humility of mind;' but in this case *nature* must be taken in its largest sense 'as including every agency which we see entering, or can conceive from analogy as capable of entering, into the causation of the world,'—in other words, nature must not be regarded 'in the narrow sense of physical (inorganic or unconscious?) nature,' for in this sense the human mind and will would be excluded from the range of things natural, although 'the agency of man is of all others the most natural, the one with which we are most familiar, the only one, in fact, which we can be said even in any measure to understand.' But the agency of man is bounded by his knowledge of natural laws, and of these laws he can only 'guide in a limited degree the mutual action and reaction. His ability to use them further is limited both by his want of knowledge, and his want of power.' Yet even so far as it already extends, scientific knowledge, which can present 'an endless series of wonderful phenomena (such as ice frozen in contact with red-hot crucibles) not belonging to the ordinary course of nature,' may be conceived as receiving hereafter an increase which may enable it to do many things which now would appear supernatural.' Still, to whatever extent this developement may be carried, we do not reach 'that idea of the supernatural which so many reject as inconceivable.' 'What, then,' the writer asks, 'is that idea? Have we not traced it to its den at last? By supernatural power do we not mean power independent of the use of means, as distinguished from power depending on knowledge, even infinite knowledge, of the means proper to be employed? This is the sense, probably the only sense, in which the supernatural is, to many minds, so difficult of belief. No man can have any difficulty in believing there are natural laws of which he is ignorant, nor in conceiving that there may be beings who do know them and can use them, even as he himself now uses the few laws with which he is acquainted. The real difficulty lies in the idea of will exercised without the use of means, not in the exercise of will through means which are beyond our knowledge. But have we any right to say that belief in this is essential to all religion? If we have not, then it is only putting, as so many other hasty sayings do put, additional difficulties in the way of religion.' If, as the writer argues, we have no certain reason for believing that God ever acts without means, then 'extraordinary manifestations of His will, signs and wonders, may be wrought, for aught we know, by similar instrumentality, only by the selection and use of laws of which man knows and can know nothing, and which, if he did know, he could not employ.' If, then, we 'once admit that there is a Being, who (irrespective of any theory as to the relation in which the laws of nature stand to His own will) has at least an infinite knowledge of those laws and an infinite power of putting them to use, then miracles lose every element of inconceivability.'

On this it has been remarked that, inasmuch as no miracle whatsoever can on this hypothesis be regarded as breaking in upon the constitution and course of nature, all those alleged miraculous events which seem to exhibit the working not of higher but of lower laws than those which govern the ordinary sequence of events must be excluded from the class of miracles, while at the same time the credibility of all narratives of miracle becomes a question of historical evidence, and of historical evidence only; that if, after being subjected to all the tests of historical credibility, these narratives emerge from the ordeal as unscathed as the history of the Peloponnesian war by Thucydides, then the miracles which they may relate may be referred to a class of events belonging to a higher range of causation; but that, if they fail under the tests applied to them, if it appear that the witnesses are prejudiced, or enthusiastic, or untrustworthy, or that the evidence is not that of contemporary witnesses, or that from any cause they may not thoroughly be relied on, then the alleged miraculous events must be put aside as not calling even for discussion.

But, further, it has been maintained that this argument which ascribes to all miracles a merely relative nature, reduces the matter to a question of words, inasmuch as a miracle which is not an absolute miracle is, in strictness of speech, no *miracle* or object of astonishment at all; that, although we cannot pretend to understand the laws of gravitation, no one pretends that that law is a miracle, and that the assertion that an event exhibiting the action of a law higher than that of gravitation is a miracle, does nothing more than extend the region of merely verbal controversy. For, on this principle, it seems to follow that no miracle can break in upon the strict continuity of causation, while, if it does break in upon it, 'it becomes unmeaning and self-contradictory, as implying imperfection in a perfect government, disorder in inevitable order, something overlooked and unexpected in the plans of supreme wisdom, requiring interpolation and revision.'

But, again, the idea of miracle, even in the relative sense, was, it is argued (Mackay, *Tübingen School*, 34), 'from the first compli-

cated and impeded by the general belief in demoniacal agency and sorcery, so that an ulterior criterion was wanted to distinguish true miracles from false or diabolical ones. This could only be found in the moral character of the work, or the beneficent tendencies of the accompanying doctrine, and the fathers were thus for several reasons induced to disparage mere signs or external displays of power, and to appeal to the doctrine to prove the miracles on which it was ostensibly based. This, however, was to refer the entire question of revelation to the paramount adjudication of conscience, and Protestant theology was obliged to lay the more stress on the primitive miracles as it repudiated later ones.'

At this point we are brought to the question of biblical miracles as distinct from those which have been termed ecclesiastical. Between these no positive line of demarcation has been laid down; but Dean Milman (*History of Latin Christianity*) discerns in the Scriptural miracles characteristics which he is unable to find in those of post-apostolic ages. Dr. Newman, on the other hand, in his well-known *Essay on Ecclesiastical Miracles*, prefixed to the Oxford translation of Fleury's *Ecclesiastical History*, argues that the Biblical and ecclesiastical miracles must stand or fall together, that the characteristics of both classes of events are essentially the same, that if some of the ecclesiastical miracles are extravagant and grotesque, the same features are found in some of the miracles related in the Bible, and that miracles such as the distillation of healing oil from St. Walburga's bones, may be paralleled by the miracle wrought by the dead bones of Elisha. On the hypothesis that the biblical miracles are all true, it was argued that 'the multitude of false miracles ranged alongside of the inspired narratives left the true miracles contained in the latter just where they are now; their truth was not affected by the fabrication of the others, and they challenged to themselves the belief of all men as imperatively as they do now. The question, then, is no longer one of authority but of evidence, and according to the quality of that which is offered a miracle must either be accepted unhesitatingly or be held in abeyance, or regarded as doubtful, or rejected altogether.' (Cox's *Life of St. Boniface*, appendix i. p. 143.)

From this historical argument, founded on the hypothesis of absolute miracle, we have to return to the argument relating to the possibility of even relative or notional miracles. On this subject it was maintained by Spinoza that 'in the view of reason there cannot be two crossing and contending wills and principles in God, that nature's law is itself the continuous manifestation and accomplishment of necessary and immanent perfection, and that to suppose anything really contradicting this perfection, or performed by the Deity in opposition to it, were to make Him contradict Himself.' If, again, God and nature were regarded as two separate agencies, operating exclusively of each other, yet 'if both powers be recognised as acting necessarily and unitedly, miracle ceases to have any objective meaning, and is really only a showy costume invented to disguise the inanity of human ignorance.' (Mackay, *Tübingen School*, 37.)

On the way in which these two questions of absolute and relative miracle are solved, must depend the character of revelation and the meaning assigned to the word. If the idea of absolute miracle is maintained, revelation will be regarded as knowledge imparted in an extraordinary manner implying a violation of natural laws; although after such promulgation it may be left to work in accordance with the ordinary course of things. On the hypothesis of relative or notional miracle, it will appear an unbroken and continuous process, coextensive with the existence of mankind from its beginning to its close, a work of which some part was accomplished when language became capable of expressing the several relationships of family life, and of which a higher stage was reached, when, possibly in a much later age, 'the conception of a Creator, a Ruler, a Father of man, when the name of God was for the first time uttered in this world.' (Max Müller, *Lectures on Language*.) [MONOTHEISM; POLYTHEISM; SUPERSTITION.]

The well-known argument of Hume, on the inherent incredibility of all miracles grounded on the continuity of nature, has been turned by Mr. Mozley, in the work already cited, against those who use it. In his opinion, no ground of reason can be assigned for the expectation 'that any part of the course of nature will the *next* moment be like what it has been up to this moment,' the belief that it will so continue having 'no more producible reason for it than a speculation of fancy.' The inductive principle, he asserts, stands on no surer basis; and hence he argues that the ground is gone upon which it could be maintained that miracles, as opposed to the order of nature, were opposed to reason. His conclusion is that 'when there is nothing on the side of reason opposed to the expectation of likeness, as is the case commonly, we follow it absolutely. But supposing there should arise a call of reason to us to believe what is opposite to it; supposing there is the evidence of testimony, which is an appeal to our proper reason, that an event has taken place which is opposed to this impression; it is evident then that our reason must prevail in the encounter, i.e. that if there is on one side positive evidence, the antecedent counter-expectation must give way.'

To this argument it has been objected, by those who consider it 'unanswerable as an argumentum ad hominem,' that it leaves to miracles, as such, no value whatever. 'If we dissever the connection between cause and effect, we denude the miracle of all meaning. A miracle has only meaning on the supposition of noumenal agency or real causation; it is on this supposition alone that we can draw the inference

of a supernatural cause.' Hence it is affirmed by such objectors that 'Mr. Mozley has only developed in one direction the inherent scepticism of the empirical philosophy.' (*Christian Remembrancer*, October 1866, p. 509.) From another point of view, Mr. Mozley's argument takes us from the ground of philosophy to that of history; and by those who take this ground it has been asserted that, where an alleged event breaks a continuity universal in all scientific experience, the evidence for that event must be adequate both in amount and quality, and that no valid argument can be raised on testimony found in books of which the historical character is not thoroughly established. The argument for alleged miraculous events is thus brought back to the general credibility of the narratives which relate those events.

Supersedeas (Lat.). In Law, a writ that lies to stay various ordinary proceedings.

Superstition (Lat. superstitio; according to some, *the standing still over a thing* in admiration or awe, while others take the word to mean *a clinging to old ground*). Superstition may perhaps be ultimately defined as belief not in accordance with facts. This is, obviously, an essential definition which leaves out of sight certain characteristic features which mark the superstitious man in all times and countries. It is, of course, possible that the seeds of superstition involved in erroneous belief may, from want of a congenial soil, fail to produce any fruit, nor can all erroneous opinions be regarded as furnishing a basis for superstitious practice. A man who should believe that some birds have four legs would entertain an opinion not in accordance with known facts, but he would not be considered superstitious, unless he added to this the notion that birds with four legs appeared from time to time to plague men, and that under certain circumstances or in certain places he might himself suffer from their attacks. Hence superstition has sometimes been said to consist in a physical dread of the unknown; and undoubtedly the passion of terror is largely fed by superstitious beliefs in general. But such an explanation fails apparently to account for all the phenomena, and the affection of terror is at best a consequence and not the cause of the superstition. The beings which a superstitious man dreads may be, in the vast majority of instances, repulsive or terrific; and hence he may be more taken up with efforts to avert their wrath than to secure a kindness which he thinks them incapable of feeling. But the man who holds, as the Greek held, that every tree, stream, or glen had its nymph, and that these nymphs were beautiful and benignant beings, whose kindly offices men might secure by paying them certain honours, is not less a superstitious man because his superstition may not exhibit the characteristic of terror. Nor can the dread which some superstitious men feel be always considered in strictness of speech a dread of the unknown. The most degrading superstitions spring out of the belief of men who have no doubt whatever as to the absolute accuracy of the map which they draw of the unseen world, and who consider themselves not less possessed of a real knowledge of the nature and habits of angels, demons, fairies, dragons, and other beings, than that which we suppose to be furnished by the maps of the Ordnance Survey.

It would seem, then, that, although belief not in accordance with fact furnishes the basis of superstition, such belief cannot issue in superstitious practice, until or unless the thing which is the object of belief is regarded as capable of injuring or helping the thinker: and inasmuch as superstitious action may spring from notions which in themselves seem most unlikely to lead to such a result, every question connected with superstitious practice becomes ultimately a question of fact. A train of the closest and most consistent reasoning may be deduced from the assumed existence of chimæras, but unless it has been proved that chimæras do in fact exist, the whole argument is fallacious, and all who receive it involve themselves in a belief which may at any time issue in superstitious practice. From this it seems to follow that the deductive method of science is not free from the element of superstition. As long as the cosmos was interpreted, and the motions of the planets explained according to some arbitrary hypothesis, an outgrowth of superstition, based on the science, was kept in abeyance only by the nature of the hypothesis. If the latter professed to account for a long series of complicated phenomena on the ground of observed sequences, it approached more nearly the character of a true science, and in the same degree was removed from superstition. We may safely assert the impossibility of basing any superstitious belief on the Heliocentric System of Aristarchus of Samos. But the hypotheses of many of his predecessors, and of some among his contemporaries and successors, furnished a fruitful source of false ideas, from which might issue at any time the most absurd or revolting superstitions. The idea of Heracleitus that the stars were fed by exhalations from the earth, that the sun was a bowl not wider than a man's foot; the notion of Xenophanes that the stars were fiery clouds, lit at night like coals and put out in the morning, and that the sun, resembling these in substance, was likewise renewed every day; could by no possibility lead to any wholesome result, and might be followed by the worst extravagances. It would be necessary only to embody in human shape the being whose office it was to light the stars at night and put them out in the morning, in order at once to introduce a system of magical rites which should appease his anger or win his favour.

The superstitious element, whether in belief or practice, lies, therefore, not in the chain of arguments which may be adduced in their favour, but in some primary hypothesis which is not in accordance with facts. If it be granted or proved that there are devils, and they act in a particular way, there is nothing at all superstitious in the conclusion that they

carried witches through the air to diabolical festivals in the Harz mountains, or in the reasoning which from these premisses established the prevalence of WITCHCRAFT as well as the enormity of the sin. [RATIONALISM.] The hypothesis being accepted, the reasoning might be indefinitely forcible, and the gravest and wisest of judges admitted that they found themselves altogether unable to resist it. The assertion that there is a Great First Cause for all things, and that this Cause is Mind, is altogether in accordance with every fact or phenomenon known to us, and hence this conviction is not only free from the slightest character of superstition, but is the strongest and ultimately the only safeguard against it. In proportion as we recede from this conviction, and from all that is by direct reasoning involved in it, we open the doors to all conceivable superstition; nor can we affect to treat with mere contempt the reasoning which underlies the horrible instances of mediæval superstition which Hallam has collected, *Middle Ages*, ch. ix. part i. The anecdotes there told of effects produced by the prayers and operation of the Virgin Mary are at the worst extravagant results from an unproved and therefore unwarranted hypothesis.

It follows, finally, that every belief and every practice not based on, or not in accordance with, actual fact, must have an injurious effect on the mental and moral state of the thinker or actor. How great may be the amount of mischief so produced, and how far it may check the growth of all literature, art, and science, the reader may gather from the chapter of Hallam already cited.

Of the other aspects of the subject, some have been noticed in the articles on MONOTHEISM, MYTHOLOGY, POLYTHEISM, and RATIONALISM.

Supertonic (Lat. super, *above*; tonus, *a tone*). In Music, the second above the keynote.

Supination (Lat. supinatio, *a bending back*). The art of turning the palm of the hand upwards by rotating the radius upon the ulna.

Supines (Lat. supinus, *on the back*). In Grammar, a name given to two cases of verbal substantives in Latin, the active supine being the accusative, and the passive (the introduction of which is unnecessary) being the ablative. The former has the same power of government with the verb to which it belongs, and it expresses a purpose, as *ire spectatum monumenta regis* (Hor. *Od.* i. 2).

Supplement (Lat. supplementum). In Geometry, the supplement of an arc is its defect from a semi-circumference; the supplement of an angle is its defect from two right angles. Two *supplemental angles* are together equal to right angles.

SUPPLEMENT. In Literature, an addition made to any work or treatise, in the view of rendering it more complete.

Supplemental Triangles. [SPHERICS.]

Supply (Lat. suppleo, *I fill up*). In Finance, the appropriation of all the sums voted annually by parliament in a committee of the whole house is known by this name. The practice dates, in effect, from the Revolution, and is looked on as one of those safeguards by which the administration is kept in check by the votes of parliament.

The known or probable amount of the different branches of the year's expenses is stated to the House of Commons in a committee of supply by the Chancellor of the Exchequer, and after the several items have been voted by the committee they are formally granted by an Act of Parliament, called the Appropriation Bill. The granting of the annual supplies is a peculiar privilege of the House of Commons, which never permits any alteration or amendment (except merely verbal) to be made by the House of Lords in the bills passed for this purpose.

SUPPLY. In Political Economy, the response to demand for commodities, the second term in the equation of exchange. Demand precedes supply, and may exist in a very urgent degree without it. It is often the case that the persons requiring supply are unable to perform their part in the exchange, either because they do not produce, or because that which they produce is not itself in demand. Such cases are not indeed objects of economical enquiry, since the demand is not effectual. Or, on the other hand, the demand may be urgent, and the elements contributing to an exchange may be abundantly present, but the supply may be wanting, because some of the conditions, under which alone supply is accorded, are deficient. But as in industrial communities the fulfilment of supply, by importation from foreign sources of such articles as are not produced by the community, or are not produced so cheaply and abundantly, is of paramount importance, it may be to the purpose to state and explain the conditions under which supply is forthcoming in sufficient amounts to meet the demand created for it.

First, then, capital must exist in sufficient abundance for the purpose of answering demand. Commodities are exchanged against commodities, and objects of value are appropriated by labour. But any natural condition of supply may be present, and even labour itself may be abundant; but in the absence of the capital necessary to set labour in motion, no response may be made to the demand. Now, in countries where but little industrial activity exists, and but scanty accumulations of capital are made, or where foreign capital, either by reason of ignorance or distrust cannot be imported, it may be very difficult to divert any portion of existing capital towards the supply of a new demand, however urgent the demand may be. For instance, during the last four years the demand for raw cotton has been exceedingly great. The prices of this material rose in the case of the better qualities to four or five times their common rate. There is, perhaps, no article the geographical range of which is wider than that of cotton. It can be

grown from the equator, upwards and downwards, to a considerable portion of the temperate zone. It is, moreover (at least some of its best species are), an annual plant. The profit on the cultivation of the crop would have been enormous. But though it is clear that to some extent the cultivation of cotton was checked by the general error into which European governments fell as to the resources of the Southern Confederacy and as to the perseverance of the North, much, it cannot be doubted, of this incapacity to meet the demand created was due to the difficulty of finding capital for the office.

Next, the area of supply must be sufficiently wide, not only possibly but actually. By far the larger portion of the cotton supply was derived, as is well known, from the Southern States of the American Union. A very small quantity came from the rest of the American continent; and an amount, tolerably large, but of an inferior staple, was imported from Egypt and India. Now, when the supply of any great necessary of life or of industry is accidentally produced from a narrow area, the importation is liable to two interruptions; those, namely, of deficient crops, and of the enforced cessation of commercial intercourse. Cotton, like any other kind of agricultural produce, is liable to injury from weather, and to the ravages of insects, and from time to time both these causes have operated to diminish and even almost to annihilate the supply from America. Again, as we have lately understood, it is possible to create and maintain so strict a blockade over a great line of coast, as to reduce the exports of bulky goods to a minimum. We do not, of course, know what amount was exported by blockade runners, but we are certain that it was wholly insufficient to affect prices or to alleviate the scarcity and distress consequent upon the deficiency. If, however, the area of supply had been wide, no such inconvenience could have happened. The price of the raw material might have risen considerably, if a large contributory had suddenly ceased to export, but the void would have been rapidly filled up. As far as regards political contingencies, we may perhaps anticipate that we are so far advanced in civilisation as never for the future to go to war with the whole world, as we almost did during the later years of the great continental war, when, in addition to our European enemies, we were at variance with the United States. The most immediate and obvious illustration of the advantage of having a wide area for supply is cotton, but that of corn is still more important, and, happily, is less liable to interruption on a large scale, than any other commodity. While corn is produced in many regions, and is freely imported, the deficiency of the season in one locality may be compensated by increased production in another, dearths being almost always of limited extent. For instance, to take an example from remote times, the years 1315–16 were times of absolute famine in England, but if Cibrario's figures are to be trusted, of plenty in Northern Italy. Similarly, the supply of wheat in the harvest of 1863 was exceedingly scanty in England, but singularly abundant in the western states of America. In connection with these facts, it may be mentioned, that there is scarcely any commodity of importance which is produced in single localities, and which, therefore, may appear open to an export duty, while it is quite certain that there is no necessary of life which is produced in one country only, or under one political régime.

Next, the producer must be secure, ordinarily speaking, of such a market as will compensate him for the cost of production, according to the ordinary rate of profit ruling in the producing country. An uncertain or a fluctuating market is the bane of supply. Thus, for instance, during the existence of the corn laws, it was impossible for the foreign producer to determine whether the produce of any year would be admitted to the English market. A maximum price was fixed at which corn could be imported, and when the price fell below that amount a varying duty was levied. Under such a system no one could anticipate whether, in case he cultivated or exported grain, he might be sure of any sale in England. Hence in years of large foreign production, grain was accumulated in bonded warehouses, the most expensive and the most unfit granary conceivable, to be often destroyed and wasted. Under such circumstances it was not likely that a trade in foreign corn could flourish, or that the English market should be at all supplied.

Lastly, the means of transit or carriage must be provided. We have already [RAILROADS] adverted to the economical effects of cheap and efficient land carriage, and shown how greatly these means reduce the cost of articles to the consumer, and thereupon create an extended market to the producer. The same reasoning applies to cheap and efficient carriage by sea. Scientific observation may result in conclusions involving the largest benefits to mankind. To take an example: In 1770, Franklin, by means of information obtained from one Folger, a Nantucket whaler, as to the course of the Gulf Stream, obtained a rude chart of its geographical position. Folger had noted the stream because no whales are ever found in its warmer waters, but always on its margin. Before this discovery the voyage to the northern part of the American colonies was always long, hazardous, and expensive, and in winter-time almost impracticable. For political reasons Franklin concealed his discovery till 1790. The effect of the publication which he made at that date was to change completely the character of the trade, and to transfer European traffic from Charleston to the northern ports. Captain Maury, whose work on the *Physical Geography of the Sea* is, apart from its scientific merits, of profound economical interest, tells us that the result of meteorological researches is to shorten long sea voyages by 30 per cent. Ten years ago, it

was estimated that the economy of these discoveries and directions might, from a calculation of the tonnage-despatched from the United States to California, Australia, and Rio Janeiro alone, be estimated at 2½ millions of dollars. It is almost impossible to do more than guess at the general saving to the mercantile world, but it will be quite clear that any economy in carriage and transit which opens a wider field of supply is a permanent benefit to mankind, and removes to a more and more distant point the cessation of those advantages which the human race procures from the peaceful and civilising operation of reciprocal trade.

To advert, in conclusion, to the supply of cotton. The manufacturers, in an association formed for the purpose of extending the area of growth and facilitating its carriage, have complained greatly of the land system of India, and the hindrance which the traditions of the Indian fiscal system put in the way of employing capital for the production of cotton. We cannot now enter into these questions, which may be found indirectly answered under the heads RYOT; TAXATION; TITHE; but the association was certainly justified in severely criticising the supineness of the administration in leaving India without railroads, without an efficient banking system, and even without navigable rivers and canals. From a military and fiscal point of view, the neglect of such administrative duties was sufficiently reprehensible, but in an economical one far more so. There is no justification of the Indian empire, except that of necessity and duty; and it is surely a matter of the highest obligation that a European administration should not fall short of the ancient rule in promoting great industrial undertakings: it should rather be far superior to that which it has supplanted.

Support, Points of. In Architecture. [POINTS OF SUPPORT.]

Supporter. In Shipbuilding, a knee-piece of oak firmly bolted under the cat-head, to reinforce it when sustaining the weight of the anchor.

Supporters. In Heraldry, figures placed on each side of the scroll, as if to support it. In English heraldry, supporters are granted only to noblemen, or to knights bannerets, by favour of the sovereign. The origin of supporters is said to have been this: some days prior to a tournament, to prevent the appearance of unqualified persons, every knight desirous of entering the lists was required to hang up his shield upon which his arms were emblazoned, in the place assigned by the appointer of the tournament for examination by the heralds. The shields thus exhibited were guarded by the servants of their respective knights, their livery disguised by dresses representing savages, Moors, griffins, lions, &c. 'In England supporters are not granted without the express command of the sovereign; but in Scotland "Lord Lion" enjoys this privilege. They are not borne by spiritual peers.' (Boutell's *Heraldry*.)

Supposed Bass. In Music, the bass of a chord when it is not the root of the common chord or harmonic triad. It is also sometimes called the inversion of the accompanying chord.

Supposition. In Music, the use of two successive notes of equal value as to time, one of which being a discord supposes the other to be a concord. The harmony, though by rule falling on the accented part of the bar, and free from discords, requires their proper preparation and resolution; and they are called *passing notes*. Discords on the unaccented part of the measure are allowable by conjoint degrees, and it is then not required that the harmony should be so complete on the accented part. This transient use of discords followed by concords is what we, after the French, call *supposition*, of which there are several kinds.

Suppository (Lat. subpono, *I place under*). A pill or bolus introduced into the rectum, where it gradually dissolves. Opium is sometimes usefully applied in this way to allay irritation of the bladder and the neighbouring parts.

Suppression (Lat. suppressio, *a keeping down*). A figure in Grammar is sometimes so called by which words are omitted in a sentence which are nevertheless to be understood as necessary to a perfect construction: as, for instance, in most languages, the repetition of a noun is avoided where it is coupled with a pronoun in one branch of the proposition; e.g. 'This (horse) is my horse,' or 'This horse is mine' (horse). [ELLIPSIS.]

Suppuration (Lat. subpuratio, *an abscess*). The process by which pus or matter is formed.

Supralapsarians (Lat. supra, *above*, and lapsus, *a fall*). In Theology, those who assert that the fall of Adam, with all its consequences, was predestinated from all eternity. [CALVINISTS.]

Supranaturalists (Lat. supra; natura, *nature*). A name given of late years to the middle party among the divines of Germany, to distinguish them from the *Rationalists*, who exclude all supernatural manifestations from religion; and from the Evangelical party, whose tenets are of a more strict description. Thus many of the supranaturalists appear to have adopted the system of accommodation (as it is termed) in religious matters, so far as to explain away the doctrine of original sin, and other tenets commonly considered fundamental: others approximate to what are generally regarded as orthodox Protestant opinions.

Suprarenal Bodies (Lat. supra, and renes, *the kidneys*). In Anatomy, the flattened bodies situated on the upper part of the kidneys in man, and at the fore part in brutes: they are well supplied with blood-vessels and nerves, and are composed principally of simple or closed vesicles, resembling the secreting glands, except that they have no ducts. They are of disproportionately large size in the fœtal state in man and quadrumana.

Supremacy, Oath of. An oath denying the supremacy of the pope in ecclesiastical or temporal affairs in England, which by many statutes was required to be taken, along with the oath of allegiance, by persons who wished to qualify themselves for office, &c. In 1858, however, a new form of oath was substituted for the three oaths of allegiance, supremacy, and abjuration (21 & 22 Vict. c. 48), and a still simpler form was provided for the use of members of both houses of parliament on taking their seats, by the Parliamentary Oaths Act 1866.

Supremacy, Papal. [PAPACY.]

Supremacy, Royal. This term, as applied to the sovereign power in a monarchy, would appear to denote civil no less than ecclesiastical authority. In practice, however, while the civil authority of the sovereign power has never been questioned, its ecclesiastical authority has been often impugned, and the phrase in question has consequently been applied almost exclusively to the supremacy of the crown over ecclesiastical causes and persons.

There appears to be no doubt that the supremacy of the crown in ecclesiastical affairs was both theoretically held and practically asserted in the early ages of English history. In the reign of William the Conqueror the court of the bishop was separated from the hundred court by a royal charter granted under the advice of the great ecclesiastical and civil personages of the realm. In 1157 a dispute between the bishop of Chichester and the monks of Battle Abbey was decided by the king in council. The practice of appealing to Rome was first introduced into this country in the reign of Stephen, by the legate Henry of Blois, bishop of Winchester, but the ancient course of justice seems to have been restored under Henry II. by the Constitutions of Clarendon. The pope, however, still asserted and exercised a real though ill-defined authority over the church of England as an integral part of the Western church [PAPACY], and appeals to Rome once more became common, although they were never expressly sanctioned by the laws of England, and although the Statutes of Provisors and Præmunire [PRÆMUNIRE; PROVISORS] enjoin heavy penalties against those who 'do sue in the court of any other in derogation of the regality of our lord the king' (16 Rich. II. c. 5).

At the Reformation, the independence of the crown was again asserted. Appeals to Rome were prohibited by the Act of Appeals (24 Hen. VIII. c. 19) and the Act of Submission (25 Hen. VIII. c. 19), and by the latter statute the appellate jurisdiction in ecclesiastical causes was expressly vested in the crown, where, except during the reign of Mary Tudor, it has ever since remained.

The royal supremacy was declared by 26 Hen. VIII. c. 1; and the present Act of Supremacy (1 Eliz. c. 1, 'An Act for restoring to the crown the ancient jurisdiction over the state ecclesiastical and spiritual, and abolishing all foreign power repugnant to the same') provides that no foreign prince, prelate, or potentate, spiritual or temporal, shall exercise any manner of power, jurisdiction, or privilege, spiritual or ecclesiastical, within the realm or the queen's dominions; and, next, that such jurisdictions and privileges spiritual and ecclesiastical, as by any spiritual or ecclesiastical power had been or might then be lawfully exercised or used for visitation and correction of the ecclesiastical state and persons, shall for ever be united and annexed to the imperial crown of the realm.

It was not, however, till after the Restoration that the regular course of appeals in ecclesiastical suits became established in its modern form; the jurisdiction of the crown was before that period exercised for the most part by extraordinary royal commissions, culminating in the famous Court of High Commission, which was established in 1583 and lasted till 1640. Subsequently to the Restoration, the practice was for the appellant from the ecclesiastical court to petition the Lord Chancellor, praying that a commission of appeal might issue under the great seal, and be directed to judges delegates to be named at his discretion. A fresh commission issued in each case; but as the delegates were selected from a permanent list, the tribunal acquired the name of the High Court of Delegates. The delegates selected usually consisted of doctors of civil law and common law judges: it was formerly usual to add some of the bishops, but this practice was gradually disused. The High Court of Delegates was abolished in 1832, and its jurisdiction transferred to the king in council. In the following year it was enacted (stat. 3 & 4 Wm. IV. c. 41) that all appeals to the privy council should be referred to a judicial committee of the council, who should report thereon to the sovereign. This committee, therefore, now constitutes the supreme court of appeal in matters ecclesiastical. It consists of the present and past holders of certain high judicial offices, together with two privy councillors nominated by the crown, and, in cases under the Church Discipline Act (3 & 4 Vict. c. 86) the prelates who are privy councillors. The lord president summons the members of the committee who sit on each occasion. (Brodrick and Freemantle, *Ecclesiastical Judgments of the Privy Council.*)

The right of nomination to archbishoprics and bishoprics forms a branch of the royal supremacy, both as anciently understood and as now exercised. 'Election,' says Blackstone (1 *Comm.* 377), 'was in very early times the usual mode of elevation to the episcopal chair throughout all Christendom, and this was promiscuously performed by the laity as well as the clergy, till at length, it becoming tumultuous, the emperors and other sovereigns of the respective kingdoms of Europe took the appointment in some degree into their own hands, by reserving to themselves the right

of confirming these elections, and of granting investiture of the temporalities (which now began almost universally to be annexed to this spiritual dignity), without which confirmation and investiture the elected bishop could neither be consecrated nor receive any secular profits. This right was acknowledged in the emperor Charlemagne, A. D. 773, by Pope Hadrian I., and the council of Lateran, and universally exercised by other Christian princes; but the policy of the court of Rome at the same time began by degrees to exclude the laity from any share in these elections, and to confine them wholly to the clergy, which at length was completely effected, the mere form of election appearing to the people to be a thing of little consequence, while the crown was in possession of an absolute negative, which was almost equivalent to a direct right of nomination. Hence, the right of appointing to bishoprics is said to have been in the crown of England (as well as other kingdoms in Europe) even in the Saxon times, because the rights of confirmation and investiture were in effect (though not in form) a right of complete donation. But when, by length of time, the custom of making elections by the clergy only was fully established, the popes began to except to the usual method of granting these investitures, which was *per annulum et baculum*, by the prince's delivering to the prelate a ring and pastoral staff or crosier, pretending that this was an encroachment on the church's authority, and an attempt by these symbols to confer a spiritual jurisdiction.'

It is quite beyond the limits of these pages to trace the history of the contest which long prevailed between the popes and the temporal powers of Europe with respect to ecclesiastical investitures. Eventually, the question ended in a compromise, by which the sovereign received only homage from the bishops for their temporalities, instead of investing them with the ring and crosier, retaining nevertheless the substantial power of nomination.

In England, however, King John surrendered by charter to the cathedral chapters the free right of electing their bishops, reserving to the crown only the custody of the temporalities during the vacancy, the form of granting a license to elect (on refusal whereof the electors might proceed without it), and the right of approbation afterwards, which was not to be denied without a reasonable and lawful cause. These privileges were confirmed by Magna Charta, and continued till the Reformation. The bishops elect were confirmed by the archbishop from the charter of King John to the reign of Edward III., after which period the pope superseded the archbishop.

At the Reformation, the right of nomination was again vested in the crown, and a curious system of forms established, which remains to the present time, it being enacted (25 Hen. VIII. c. 20) that on the avoidance of a bishopric the king may send the dean and chapter his license to proceed to election (congé d'élire), which is to be accompanied by a *letter missive* from the king containing the name of the person he would have them elect. If the election be delayed above twelve days, the nomination lapses directly to the crown. The person elected is confirmed, invested, and consecrated by the archbishop; but it was decided in 1848, in the celebrated case of Dr. Hampden, that the function of the archbishop is ministerial only, and that he has no power to take cognisance of any objections to the person presented to him.

Previously to the year 1850, the Roman Catholics in England had for many years been under the authority of vicars apostolic appointed by the pope. These were, in fact, bishops; but in order to avoid the jealousy of the civil power their titles were taken from places abroad, and the word *district* was used instead of *diocese*, to express their local jurisdiction, submission to which was, of course, voluntary only. In Ireland and the colonies, however, the Roman prelates had long assumed the episcopal title. In the year 1850 the pope issued letters apostolic dividing England into formal dioceses, and appointing a bishop or archbishop to each. This measure (commonly known as the *papal aggression*) caused great excitement at the time, and an Act was passed (14 & 15 Vict. c. 60) imposing penalties on persons assuming the title of archbishop or bishop of any place unless authorised by law. The Act, however, can only be enforced with the consent of the Attorney-General, and it has been quietly allowed to become a dead letter, no prosecution having been instituted under it, although the English Roman Catholic bishops habitually use territorial titles.

The royal supremacy has been considered to extend to the colonies, and numerous bishoprics (endowed for the most part from private sources) have been established there by the crown under letters patent, and the crown has in the same manner appointed bishops to the different dioceses, some of whom have been invested with a metropolitan or superior jurisdiction. It has, however, been recently decided by the Privy council in Mr. Long's case (1863) and the Natal case (1865) that letters patent issued by the crown after the establishment of a constitutional government in any colony are ineffectual to create therein any legal diocese, subject to coercive ecclesiastical jurisdiction, or any ecclesiastical corporation whose status, rights, and authorities the colony can be required to recognise. 'The church of England,' Lord Kingsdown said, in giving judgment in Long's case, 'in places where there is no church established by law, is in the same situation with any other religious body, in no better but in no worse position, and the members may adopt, as the members of any other communion may adopt, rules for enforcing discipline within their body, which will be binding on those who expressly or by implication have assented to them.' (See further the case of Colenso *v.* Gladstone, decided in Chancery, Nov. 1866.)

Sura. The Arabic name for the chapters of the Koran. These chapters were, it is asserted, given forth sometimes as a whole, sometimes in driblets, and often in single verses. Such driblets Mohammed, it is said, directed his amanuensis to enter 'in the sura which treated of such and such a subject.' If this tradition be authentic, it would indicate that Mohammed wished the Koran to be arranged according to its matter, and not chronologically; and hence the difficulty of assigning dates to each sura or portion of a sura is indefinitely increased. The arrangement is made, therefore, in the absence of other proof, to rest mainly on internal evidence, the various phases in his life, so far as we can be said to have any knowledge of it, being illustrated by the various chapters of the Koran. This perilous task has been attempted by many writers; with more than average success by Mr. Muir, in his *Life of Mahomet*, to which the reader is referred for a review of all the literature relating to the Prophet of Islam. According to Mr. Muir's canon, the earliest suras are vehement and impetuous fragments, while in those of a later date the style becomes calmer and more uniform; with the decay of really sincere and earnest feeling, the suras become more lengthy and elaborate; and the theory of inspiration is more fully developed. Thus, the passages in which reverence is claimed for the Koran, by ascribing to it not Divine inspiration only, but a heavenly original, belong to a later time than those in which the prophet speaks of himself simply as declaring the will of the Most High. It is obvious that with such uncertain materials the conclusions of independent writers must be more or less antagonistic; and the manipulators of the Koran have not escaped the criticism which commonly falls to the lot of those who attempt to determine the chronological order of facts, for which we have not adequate evidence in contemporary documents.

Surbase (Fr.). In Architecture, the upper base of a room, or rather the cornice of the dado.

Surcharged or Overcharged Mine. In Military Mining, a mine loaded with a very great charge of powder. It is sometimes called a *globe of compression*.

Surcoat (Fr. sur, *over*, and Eng. coat). A garment, generally of silk, forming part of the knightly equipment of the middle ages, from the thirteenth century. [CYCLAS; JUPON.] It was worn over the body armour, and was originally designed to defend the armour from wet.

> Gay gownus of grene
> To hold thayre armur clene
> And were· hitte fro the wette.
> *The Avowynge of King Arther*, stanza 39.

Surd (Lat. surdus, *dull*, *silent*). In Arithmetic and Algebra, a magnitude which is inexpressible by rational numbers. Thus, the square root of 2, the cube root of 3, &c., are numbers which cannot be expressed exactly in the ordinary notation, and are represented by prefixing the radical signs indicating the operation, viz. $\sqrt{2}$, $\sqrt[3]{3}$. Such quantities are otherwise called *irrational* or *incommensurable*.

Surf. [WAVE.]

Surface (Fr.; Lat. superficies). In Geometry, the boundary of a solid, or that which has length and breadth, but no thickness. A surface may be conceived to be generated by the motion of a straight or curved line, just as the latter may be generated by the motion of a point. A surface is said to be *plane* when a right line can be applied to it everywhere and in every direction: in other cases it is called a *curved surface*. Surfaces generated by the motion of a right line are called RULED SURFACES, in which family are included DEVELOPABLE SURFACES and SKEW SURFACES. A curve by rotating around an axis generates a *surface of revolution*. [REVOLUTION.] Several other distinctive names are given to surfaces according to their peculiar properties or modes of generation; these being noticed in their proper places, we have only to add here that the most general classification is that into *orders* and *classes*. The *order* of a surface is the number of points, real or imaginary, in which it is cut by any right line; in other words, the degree of the equation which is satisfied by the co-ordinates of its several points. By the *class* of a surface is meant the number of its tangent planes which pass through any given line. Surfaces of the second order are also of the second class; but in general order and class are different. Surfaces whose equations involve transcendental functions of the co-ordinates are termed *transcendental*, to distinguish them from *algebraic surfaces*, to which alone the term *order* can be applied. One of the most complete English treatises on surfaces is contained in Salmon's *Analytical Geometry of Three Dimensions*, Dublin, 1865.

Surface Condensation. A method of condensing the steam discharged from an engine by means of cold metallic surfaces like those of a still, to the end that the water thus recovered may be used again to feed the boiler. The benefit of this practice in the case of steam vessels is, that the boiler being fed with pure distilled water, instead of with salt water from the sea, the risks of salting the boiler are prevented, and higher pressures of steam may be used with safety. Common sea water deposits sulphate of lime without undergoing concentration when the temperature is increased to a point answering to a pressure of 40lbs. per square inch; and if scale be suffered to accumulate on the flues or furnaces of a boiler maintaining a high pressure, the flues may become red hot and collapse, or, in other words, the boiler may burst. Now, as a high pressure of steam is necessary to the efficient application of the principle of expansion, and as fresh water in the boilers is the necessary antecedent of high pressures, the principle of surface condensation acquires great importance in steam navigation, although the

benefits of the system have not yet been fully developed. The condensation is usually effected by discharging the steam against a faggot of pipes through which cold water is made to circulate by a pump. The pipes at their ends pass through a metal plate in which they are made tight either by a small stuffing box and screw at each, by the application of a perforated sheet of Indian-rubber pressed down by another perforated plate above, or by the interposition of a ferrule of compressed pine between each pipe and the plate; the water swells the wood and makes the joint tight. The pipes are usually made of copper or brass, and should be tinned externally to prevent galvanic action on the boiler. [STEAM NAVIGATION.]

Surgeon. In the Army, the officers of the medical department are classed as follows: Director-general, who ranks as a major general; inspector-general, as brigadier-general, or, after three years' service, or in the field, as major-general; deputy inspector-general, as lieutenant-colonel—after five years' service, as colonel; surgeon-major, as lieutenant-colonel, but junior of the rank; surgeon, as major; assistant-surgeon, as lieutenant—after six years' service, as captain. Each regiment of cavalry and battalion of infantry has a surgeon and an assistant-surgeon. Staff-surgeons and assistant-surgeons are usually employed at the general and garrison hospitals at home and abroad.

Surgeon, Naval. An important officer in the economy of a ship. In the Royal Navy there are the following grades: inspector-general of hospitals and fleets, deputy-inspector, staff-surgeon, surgeon, assistant-surgeon. The whole service is organised under a director-general, who sits at the Admiralty. In the merchant service no well-appointed ship of any size above a mere coaster or schooner sails without a surgeon.

Surgery (Gr. χειρουργία, *a working by hand, the practice of an art*). This word, in its modern acceptation, may be defined as the practical application of medical science, in the use of all mechanical or instrumental means, for the removal of diseases and the relief of human suffering.

If it be true that man is impelled by an instinctive impulse to seek for some natural remedy for his bodily disorders, the practice of medicine must for some time have existed before the dawn even of the rudest deductive theories. The wish to cause vomiting in order to relieve nausea would impel the sufferer to seek for something which would act as an emetic, and the discovery of such a thing might be either imparted to his fellow-men or kept secret as a means both of profit and power. In matter of fact, the knowledge of herbs and simples so acquired seems in all countries to have been confined to a small class, which in the sequel assumed all the powers of a caste, and was generally identical with the priesthood. In this, which may be termed the sacerdotal stage of medicine, the hierarchy, possessed of a certain knowledge not shared by the great body of the people, and having no interests which might be hurt by the extension of that knowledge, affords a valuable aid to the growth of medical science. But the observation that remedies act in a given way, being effective in some cases and useless in others, leads to the idea of an orderly and regular causation, and the theories of the miraculous or supernatural characters of diseases begin to lose their original power and charm; and although the student of medicine may try to avert opposition by declaring that all causes with all their consequences are equally divine, an instinctive feeling warns the priestly caste that the advance of such notions must insure their downfall, and leads them to an uncompromising antagonism.

This speculative or sceptical stage of the science, if summarily arrested, will be followed by an effete stagnation, like that which followed the extinction of Saracenic science in Spain: but if the efforts for repression fail, the growth of a genuine scientific school has for its result a large accumulation of observations, and of knowledge derived from experiment, which may again bring it into collision with theologians and deductive reasoners.

These several stages may be traced with more or less exactness in the history of medical science amongst the Greeks and Romans, in Egypt and Spain, in mediæval Europe, in the Eastern world, and in the modern states of Europe and America. The Ayur Veda of the Hindus embodied the medical knowledge of the priestly caste in a form analogous to that of the Egyptian priesthood, and as this system has retained its hold to the present day their medical science exhibits still the features which marked it two or three thousand years ago.

In the Greek legends, the tales of Cheiron and Asklepios (Æsculapius), of Heracles, Podaleirion, and Melampus, illustrate that mythical era of medicine to which SANCHUNIATHON and his alleged writings may be assigned. The remedies applied by the school which assumed the name of Asklepios were, as we might expect, altogether empirical, and their unscientific character called forth the Aristophanic satire, which represented the Asklepiadæ as stealing during the night the offerings of their dupes. The Pythagoræan schools (whether Pythagoras be mythical or historical) worked to better purpose, and came accordingly into conflict with the traditional dogmas of ruling classes. The men who on recovery from sickness put up a votive tablet to some deified hero, whom they regarded as their healer, could not well tolerate a system which applied a specific remedy to a specific evil in the anticipation of a merely natural result.

That Greek medicine had reached its speculative or sceptical stage is abundantly attested by the doctrines of Hippocrates, who 'treated all phenomena as at once both divine and scientifically determinable. (Grote, *History of Greece*, part i. ch. xvi.) Of all diseases he affirmed that 'none is more divine or more

human than another, but all are on the same footing, and all divine; nevertheless, each of them has its own physical conditions, and not one occurs without such physical conditions.' It is obvious that one who so spoke might profess to start with or uphold some deductive theory, but his science pointed wholly to observation and experiment, and took no cognisance of any causes beyond those which might be ascertained by human industry and research. Hence Hippocrates necessarily made light of all hypotheses which connected the study of medicine with astronomical phenomena, and insisted that medicine should be determined by and bear reference to its own end, i. e. to the nature of man, as ascertainable by practical examination. This method marks especially the Hippocratic treatise on Climate as affecting the developement of the human race, and the basis of his Humoral Pathology, which retained its hold on the medical schools of Europe for more than 2,000 years.

Medical science, checked in Greece by the disorders which followed the fall of Athens, received a fresh impulse in the schools of Alexandria. These schools were especially distinguished for their anatomical researches. By dissection and experiment they laid the foundation of scientific anatomy and physiology; and the advance made was so great that, while Aristotle hardly knew that there were nerves, Herophilus was enabled to demonstrate the functions of both the motor and sensitive nerves.

While medical science was thus advancing in Egypt, at Rome it had scarcely taken root, nor can the schools which sprang up in the later days of the republic and after the establishment of the empire be strictly considered Roman. They were founded by Greek physicians; and the Romans who, like Celsus, became most eminent in them, whether belonging to the Eclectic or to other sects, adopted Greek theories, or reasoned from Greek axioms. To Celsus medical science is indebted for a great advance, not only in pharmacy, but also in surgical knowledge. Roman medicine reached its culminating point when, under Marcus Aurelius, Galen sojourned in Rome. The degree to which deductive methods still influenced scientific research may be inferred from the fact that this illustrious physician belonged to the sect of the Dogmatics. Although he professed to believe that the axioms from which he reasoned were founded on facts, he yet disregarded individual facts and the detail of experience as of little value in comparison with his preconceived theories of the nature of diseases. On the whole, he adhered to the mingled dogmatism and scepticism of Hippocrates. His two fundamental maxims were: (1) that disease is something contrary to nature, and must be overcome by that which is contrary to the disease itself; and (2) that nature is to be preserved by that which has relation with nature. In his treatment, he made little of the symptoms of diseases, arguing that these would disappear with the disease as soon as the latter was conquered.

In the West, medical science, after the days of Galen, underwent a sudden and complete eclipse. In the Byzantine empire, the medical schools, after the opposition made by Christians to anatomy, consisted chiefly of copyists and commentators on Hippocrates and Galen. But the names of Oribasius, Aetius, and Procopius, are obscured by the greater fame of Paulus Ægineta, in the earlier half of the seventh century.

The independent research, which had been abandoned or stigmatised in Christian countries, was taken up by the Saracenic schools. Under Ebn Sina (Avicenna) and Avenzoar they reached their highest glory in the East and West respectively. But the victories of the Turks in the former, and in the latter the downfall of Moorish dominion in Spain, at once and finally arrested its progress.

In mediæval Europe, the genuine cultivation of medical science soon provoked the opposition of the hierarchy; and the imprisonment of Roger Bacon, with the posthumous conviction of Peter of Apono, answered to the penalties inflicted on Galileo. But when, in the person of Leo X., the powers of the papacy were wielded by one whose attachment to the traditional belief has not been considered very strong, medical science again revived, and the Greek culture then introduced insured the overthrow of the old coercive system.

This so-called revival of learning had an immediate effect on England. In 1484, Thomas Linacre, founder of the College of Physicians of London, attended at Florence the lectures of the Athenian Chalcondylas. A century later, Foes had translated the Hippocratic writings, and Fernel had questioned the dogmas of Galen.

Into the later history of the science we are precluded by our limits from entering. Some account of the most distinguished physicians and of their several discoveries may be found in the article ANATOMY. For the details of medical and surgical science, the reader is referred to the accounts given of the several diseases, and to the articles CHEMISTRY; DIGESTION; FOOD; MORPHOLOGY; NUTRITION; TELEOLOGY.

A compendious account of ancient surgery is given in the article 'Chirurgia' in Dr. Smith's *Dictionary of Greek and Roman Antiquities*. (See also the articles on Celsus, Galen, Hippocrates, in Smith's *Dictionary of Greek and Roman Biography*; *Encyclopædia Britannica*, art. 'Medicine;' Henri Martin, *La Foudre, l'Electricité, et le Magnétisme chez les Anciens*.)

Surinamine. A crystallisable alkaloid obtained from the bark of the *Geoffroya Surinamensis* (now called *Andira inermis*) or *Surinam bark*.

Surmark. In Shipbuilding, an abutment temporarily placed on the outside of a rib, or timber, to give a hold to the riband by which, through the shores, it is supported on the slipway:

Surmounted. In Architecture, a term sometimes used to denote an arch or dome which rises higher than a semicircle.

SURMOUNTED. In Heraldry, a bearing is said to be surmounted by another bearing which extends not only across it, but across the field also; therein differing from *charged*, e.g. a pile *surmounted* by a chevron; which in this case extends across the field.

Surname (Fr. surnom; Span. sobrenombre, from Lat. super, *over*, and nomen, *a name*). In modern European usage, the family name of an individual; but often used for any distinguishing name. [NAME.] According to Ducange, the use of surnames in France began about the year 987, when the barons adopted the practice of designating themselves by the names of their estates. This has been the general, though by no means the uniform origin, of family names in the nobility of Europe; some having been derived from badges, cognisances, the nicknames applied to individuals, &c. Among the commonalty of this country, surnames are said not to have been general before the reign of Edward II. It will be found on examination that a great number of them originate in the still older custom of adding to the son's Christian name that of the father by way of distinction; many more from the names of trades; and many more from accidental distinctions, as of size or colour, probably applied in the first instance to the founder of the family.

Surplice (Low Lat. superpellicium, apparently from pellis, *skin*). This ecclesiastical vestment is thought by Mr. Palmer (*Orig. Liturg.* ii. 320) to have been at one time not different from the alb. It now has wider sleeves, a difference which is thought to have originated in some distinction between the dress of a superior and inferior order of clergy. It dates from the twelfth century. The vehement objections entertained by the Puritans of the sixteenth century to its use are well known. [VESTMENTS.]

Surrebutter. [PLEADING.]

Surrejoinder. [PLEADING.]

Surrender (perhaps a corruption of Fr. se rendre, *to yield oneself*). In Law. 1. A deed by which the tenant of a particular estate or interest conveys his interest to the remainder-man or reversioner, immediately expectant on the determination of that estate, as, for instance, when a tenant for years gives up his lease to the freeholder. 2. A surrender of copyhold or customary estates is the yielding up of such estates by the tenant into the hands of the lord for purposes expressed in the surrender. This is the common method of conveying copyhold lands, the lord being in general bound to admit the party in whose favour the surrender is made. [COPYHOLD.]

Surrogate (Lat. subrogatus). In Law, one substituted for or appointed in the room of another. The term is commonly used in the ecclesiastical courts as the description of an officer who acts as deputy for the bishop's chancellor.

Surtout. In Heraldry, a figure borne over another, and obscuring part of it.

Surturbrand. A kind of fibrous Brown Coal or Bituminous Wood found in Iceland. It resembles Bovey Coal.

Surveying (Fr. survoir, *to overlook*). In Practical Mathematics, the art of determining the boundaries and superficial extent of a portion of the earth's surface. The object of a survey may be either to ascertain the contents of a field or portion of land, or to determine the relative distances and bearings of the most prominent objects of a country for the purpose of constructing a map, or to determine the form and dimensions of a portion of the earth's surface with a view to deduce the magnitude and figure of the earth by comparing the geodetical distances between given points with their astronomical positions. In all cases the operation is conducted on the same principles; but while the first requires only the application of the merest elements of arithmetic and trigonometry, the last can be accomplished only with the aid of instruments of the most refined description, and processes of calculation deduced from mathematics of the highest order.

In measuring land, all the lines and the surfaces whose contents are to be found are reduced to the same horizontal plane, on the principle that as plants shoot up vertically, no greater number can be produced on the slant side of a hill than would grow on the area covered by its horizontal base. When the lines actually measured are not horizontal, they are therefore multiplied by the cosines of their respective inclinations to the horizon.

For the linear measurements, a chain is employed consisting of 100 links, its whole length, 22 yards, being such that one *square chain* is equal to the tenth part of an acre. In order to avoid decimal fractions, surveyors usually set down all the measures in links; and when the contents of a field are cast up in square links, it is only necessary to mark off the five last figures as decimals in order to have the contents in acres, the number of square links in an acre being $100 \times 100 \times 10 = 100,000$.

As the measurement of angles is in general an operation much less liable to error than the measurement of linear distances, the skilful surveyor, in cases where the surface to be measured is of considerable extent, will avoid making further use of the chain than is necessary for obtaining the data requisite for a trigonometrical computation. The most convenient instrument, and that which is almost universally employed in land surveying for the measurement of angles, is the THEODOLITE, which, from the nature of its construction, gives the angles reduced to the plane of the horizon, and consequently renders a computation for that purpose unnecessary. As auxiliaries to the theodolite, and for the purposes of sketching and filling in the details of a map, the PLANE TABLE and the PRISMATIC COMPASS are used; and in order to determine the bearings of the several objects observed from any

station with reference to the cardinal points of the horizon, a compass and needle accompany the theodolite.

It frequently happens in surveying, that triangles are to be measured whose sides contain very acute or obtuse angles. As in such cases a small error in the angular measurement would lead to very erroneous results, the practice usually adopted for finding the area is to measure the longest side of the triangle and the perpendicular let fall upon it from the opposite angle, the area being half the product of the side into the perpendicular. For the purpose of tracing the perpendicular, the simple cross-staff may be employed; but the instrument called the *optical square* (which is merely a small shallow circular box containing the two principal glasses of the sextant fixed at an angle of 45°) will effect the purpose with greater accuracy. The method of using it is obvious. If the observer moves forward or backward in the straight line A B until the object B seen by direct vision coincides with another object C seen by reflexion, then a straight line drawn to C from the point at which he stands when the coincidence takes place will be perpendicular to A B. The box sextant might evidently be employed for the same purpose.

Since every plane figure may be regarded as composed of a certain number of triangles, the whole theory of land surveying resolves itself into the measurement of the areas of plane triangles. For computing the area of a triangle it is necessary to know the length of at least one side; and when this is known, together with any two of its other parts, the remaining parts and the area are computed by the rules of trigonometry.

In surveying an estate, the usual practice is to measure round it with a chain, and observe the several angles with the theodolite; and if the boundaries are very irregular, a straight line is to run between two points so as to cut off one or more of the bendings, and the perpendiculars or *offsets* from the straight line to each bending are measured with a rod or offset staff, the most convenient length of which is ten links. By this means the spaces included between the actual boundaries and the assumed straight lines are computed; and the sides and angles of the interior polygon being known, its area may be formed without resolving it into triangles. [POLYGON.]

Trigonometrical Survey.—When a survey is to be effected on a large scale, as for making a geometrical map of a country, or for measuring an arc of the terrestrial meridian, not only is minute accuracy required in all the practical parts of the operation, but it becomes necessary to have regard to the curvature of the earth's surface, the effects of temperature, refraction, altitude above the sea, and a host of circumstances of which the influence is wholly unappreciable in the practice of ordinary surveying. Geodetical measurements of this kind have been executed in various countries. [DEGREE.] The first undertaken in our own country was that of General Roy, begun in 1783, for the purpose of connecting the Greenwich Observatory with the French triangulation which had been carried on from Paris to the coast opposite Dover, and consequently for determining the difference of the meridians of the two observatories by actual measurement. This gave rise to a more important operation; namely, a general survey of the kingdom, begun in 1791 under the direction of the Board of Ordnance. A brief description of the methods employed in conducting the different parts of this splendid national undertaking will probably be the best means we could adopt to explain the nature and objects of an accurate trigonometrical survey.

Measurement of Base.—This is the fundamental, and probably the most difficult part of the whole operation, and must be executed with the most minute accuracy, as any error committed in its determination will affect all the distances deduced from it, and be multiplied in the ratio of these distances to the length of the base. First of all, a suitable piece of ground, on which a straight line of not less than five or six miles can be laid down, must be selected and carefully levelled; and a measuring apparatus employed, of which the length is exactly known in units of a standard scale. General Roy's base on Hounslow Heath was first measured with deal rods; but as these were found to be affected by the hygrometrical changes of the atmosphere, it was again measured with glass tubes twenty feet in length, furnished with a peculiar apparatus for making the contacts. In the subsequent measurement of the same line for the Ordnance Survey, two steel chains of 100 feet in length, made by Ramsden, were employed. One of these was used as a measuring chain; the other was kept for the purpose of comparing the measuring chain with it before and after the operation. In the act of measuring, the chain was laid in a trough supported on trestles, and was stretched with a weight of fifty-six pounds. The same apparatus was employed in measuring five other bases in different parts of the country, for the purpose of verifying the accuracy of the work. For the measurement of the Lough Foyle base in the survey of Ireland, Colonel Colby employed a compensating apparatus formed of bars of different metals, so arranged that the distance between two points viewed by compensation microscopes remains constant under all changes of temperature. The length of the Hounslow Heath base was nearly 5·2 miles; that of the Irish base about 8 miles. (*Account of the Measurement of the Lough Foyle Base*, 1847.)

Selection of Stations.—The next step in the operation is to divide the country to be surveyed into a series of connected triangles. The choice of the stations which form the angular points must depend in some measure on the nature of the country; but where circumstances admit of a selection being made, it is very important to form the triangles so that

the small unavoidable errors of observation shall produce the least errors possible in the resulting sides. The conditions required for this purpose are most nearly fulfilled by making the triangles as nearly as possible equilateral. (Galloway 'On the Determination of the most probable Errors of Observation in a portion of the Ordnance Survey,' *Mem. Royal Ast. Soc.* vol. xv.)

Signals.—Various plans have been adopted in the course of the survey for marking and rendering visible the stations at which the instrument is successively set up. At first flag-staffs were chiefly used, carrying lamps and concave reflectors for night observations. Such signals could be seen in the telescope of the great theodolite at distances of 20 or even 24 miles. Bengal lights, fixed in small sockets, were used for more distant stations. In the mountainous countries of Scotland and Ireland, and where the sides of the triangles generally exceeded 50 and sometimes even 100 miles in length, conical piles of stone were erected on the summits of hills; and although the signals were attended with this disadvantage, that they could only be seen when the atmosphere was clear (and the surveying parties were frequently compelled to remain for weeks on the mountains before a single observation could be made), yet from the steadiness of the object observed they were found on the whole to be preferable to any night signals previously tried. When the theodolite was to be set up at a station which had been already observed from another, the pile was thrown down, and the instrument placed exactly over its centre. The heliotrope, and small plane mirrors, have likewise been occasionally employed with success. (On this subject, see Mr. Drummond's paper in the *Phil. Trans.* for 1826.)

Reduction to Centre of Station.—In observing the angles at any station, it is supposed that the centre of the instrument is placed exactly at the centre of the station. This condition was rigidly adhered to in the Ordnance Survey of Britain by erecting signals on purpose; but where the saving of expense is an object, it is often convenient to take advantage of spires, towers, &c., in which case the instrument cannot always be placed in the required position. In such circumstances, the observation is made at a point near the station, and the angle at that point subtended by two remote objects is reduced to that which would have been observed if the instrument had been placed exactly at the centre of the station.

Reduction to the Horizon.—Another indispensable condition is, that the angles observed at each station be reduced to the plane of the horizon. When the theodolite is employed for measuring the angles, this reduction is effected by the instrument itself; but when the angles are measured with a repeating circle or sextant, a reduction is necessary, unless the two distant objects observed be in the same horizontal plane with the instrument, which will rarely happen.

Spherical Excess.—The sum of the three angles of any spherical triangle exceeds 180° by a quantity which is called the ***spherical excess***, and which we shall denote by E. If the observations could be made with absolute accuracy, the sum of the three observed angles of any triangle on the ground would be 180° + E; the difference of their sum from this quantity is the aggregate error of the three observed angles, and must be distributed among those angles so as to render the sum precisely 180° + E before the sides are computed. It is therefore necessary to determine E. Let S denote the area of the triangle in square feet, r the number of feet in the radius of the earth, and $\pi = 3{\cdot}14159$; then E is given in seconds by this formula [SPHERICAL EXCESS]:

$$E = \frac{S + 648000''}{\pi r^2}$$

(648000 being the number of seconds in 180°). In order, therefore, to compute E, we must previously know the values of S and r. Now with respect to S, it is to be observed that in every case which can arise in practice the area of the triangle must be a very small quantity relative to r^2, so that in order to find E it is not necessary to compute S with great precision. A sufficiently near value will be obtained by calculating one of the unknown sides as if the triangle were a plane one, and computing the area from the formula $S = \frac{1}{2}\,a\,b$ sin C. (*Measurement of Lough Foyle Base*, p. 126.)

With respect to r, which is here taken to represent the radius of curvature of the surface of the triangle in question, it is to be remarked, that by reason of the ellipticity of the earth, the radius of curvature of any arc on the earth's surface varies not only with the latitude of the place of observation, but also with the direction of the arc in respect of the meridian. For the present purpose it would be sufficiently accurate to assume r as the radius of the meridian; but as the radius of the perpendicular and oblique arcs is required in other parts of the computation, we shall here give the formulæ from which they are computed. Let R be the radius of curvature of the meridian at latitude l, R′ the radius of the circle perpendicular to the meridian, and r the radius of a great circle making an angle θ with the meridian; also let p denote half the polar axis of the earth, or 20,853,810 feet (Airy's value), and e the ellipticity, or the difference between the equatorial and polar axes divided by the polar axis ($= 1 + 301{\cdot}026 = {\cdot}003322$); then

$$R = p\,(1 - e + 3\ e \sin^2 l)$$
$$R' = p\,(1 + e + e\ \sin^2 l)$$
$$r = R\,\left(1 + \frac{R' - R}{R'} \sin^2 \theta\right)$$

Since the inclination θ is different for each of the sides of the triangle, a mean value of r may be found by making $\theta = 45°$, in which case $\sin^2\theta = \frac{1}{2}$: and as the curvature varies very little through a considerable extent of country, the same value

of r may be used for all the triangles within a zone of two or three degrees of latitude. Suppose, then, the value to be computed for the mean latitude of a chain of triangles, the formula for the spherical excess will be

$$E = \frac{a\, b \sin C \times 648000}{2 \pi r^2}$$

It is proper to remark that in general E is a very small quantity. When the sides of the triangles are about 20 or 30 miles, it will seldom exceed 4 or 5 seconds of a degree; but in some of the great triangles connecting Ireland with the west coast of Scotland its value was found to exceed 30 seconds.

Having computed the spherical excess E, make $e = A + B + C - (180° + E)$—A, B, C being the observed horizontal angles; then e is the error of the sum of the observed angles; and if there be any reason for supposing that any one of the angles has been less accurately determined than the others, the error must be equally divided among them, or a third of e must be added to or subtracted from each angle, as the error is in excess or defect, and the results will give the angles from which the sides are to be computed.

Calculation of the Sides.—The angles being thus corrected for errors of observation, it now remains to compute the two unknown sides of the triangles. The computation may be made by the ordinary rules of spherical trigonometry; but a better method, practised by Delambre, and adopted in the Ordnance Surveys of Great Britain and Ireland, consists in first computing from the observed horizontal angles the corresponding angles formed by the chords of the terrestrial arcs, and then calculating the triangle as a plane one. In this manner the chords of the spherical arcs are found, whence the arcs themselves are easily obtained.

Legendre's Theorem.—Another method of computing the sides, which has been generally adopted in surveys on the Continent, is derived from a theorem which was discovered by Legendre, and is demonstrated in his *Elémens de Géométrie*. 'If from each of the angles of any small triangle on the surface of a sphere or spheroid one-third of the spherical excess be deducted, the sines of the angles thus diminished will be proportional to the lengths of the opposite sides, and consequently the sides may be computed as if the triangle were rectilineal.' This is the easiest method of any; and, in fact, if the three angles are assumed to have been equally well determined, the previous computation of the spherical excess is not necessary for the calculation of the sides, though it will be required for estimating the relative accuracy of the observations.

Latitudes, Longitudes, and Azimuths.—When the sides of all the triangles have been computed, the distances between the stations become known; but in order to complete the survey, it is still necessary to determine the astronomical positions of the principal stations, together with the bearings of the sides of the triangles with respect to the terrestrial meridians. For this purpose the latitude and longitude of one of the stations, and the azimuth of another as seen from it, must be found by astronomical methods [AZIMUTH; LATITUDE; LONGITUDE]; but when this has been done these elements may be computed for each of the other stations in the chain of triangles, provided the dimensions and ellipticity of the spheriod are assumed to be known.

Calculation of Altitudes.—The only element which remains to be determined, in order to complete the survey, is the relative altitudes of the different stations or principal points. At every station the elevation or depression of each of the others observed from it is measured with the theodolite; but owing to the curvature of the earth and the refraction of light, a calculation is necessary in order to determine their true differences of level or of distance from the centre of the earth.

In surveying a line of railway or canal, the first thing to be done is to traverse the country intervening between the proposed termini, so as to judge by a reconnaissance, or eye survey, what is the most elegible route. A more detailed examination is subsequently made, when the levels are taken, so as to balance the earthworks as nearly as possible, and the line is then staked out. [RAILROADS.] In marine surveying, the main points are fixed by astronomical observation.

(*Trigonometrical Survey of England and Wales*; Delambre, *Base du Système Métrique*; Puissant, *Traité de Géodesie*; Id. *Nouvelle Description Géométrique de la France*; *Ency. Brit.* art. 'Trigonometrical Survey.')

Surveying, Naval. The science of determining the lines on which seas may be safely navigated. The duty consists in ascertaining the depth of water by sounding, in carefully delineating on charts the points at which the depth changes, and by observing the bearings of natural or artificial objects, which may enable navigators to determine their exact position and course.

Survivorship. In the doctrine of Life Annuities, a reversionary benefit contingent upon the circumstance of some life or lives *surviving* some other life or lives, or of the lives falling according to some assigned order. For the solution of the different questions which can be put relative to the values of annuities and assurances in every order of survivorship, where there are only three lives, see the treatises of Baily and Milne; or the 'Essay on Probabilities' in the *Cabinet Cyclopædia*. [ASSURANCE; EXPECTATION OF LIFE.]

Sus (Lat.; Gr. ὗς). The generic name given by Linnæus to those hoofed mammals which have on each foot a pair of large digits with a small one on each side, shorter, and more backwardly placed. Lower incisors procumbent, opposed to upper ones. Canines exposed, and in the males usually recurved, upward. The muzzle terminated by a truncated snout fitted for turning up the ground. Non-ruminant. This

generic name is retained for the species of wild boar and their domesticated descendants of Europe and Asia. But certain African kinds have been separated under the names *Potamochœrus* and *Phacochœrus*, and the South American kinds under the name *Dicotyles*: the whole now forming the family of non-ruminant Artiodactyles, called *Suidæ*.

Susannite. A mineral with the same composition as Leadhillite, which it also closely resembles in appearance, found in crystals on the Susanna lode at Leadhills in Lanarkshire.

Suspension. In Ecclesiastical Law, suspension from the right of exercising an office, and from receiving the emolument thereof (ab officio et beneficio), is a punishment inflicted on the clergy by sentence of the ecclesiastical court. Laymen may also be suspended ab ingressu ecclesiæ for brawling in a church, or the like, and condemned to pay the costs of the proceedings.

Suspension Bridge. In Architecture, a bridge in which the roadway, instead of being carried over the supporting points, is suspended from them, the supporting points being chains or other flexible materials. The principle has recently been carried to a great extent in this country, as in the case of the Menai bridge; but its application is old, and has long been practised among people who have attained very little if any skill in the arts. [BRIDGE.]

Sussex Marble. A variety of limestone which constitutes one of the fresh-water deposits of the Wealden group; it abounds in shells of *Paludinæ*, a genus of fresh-water Univalves. It occurs in layers varying from a few inches to upwards of a foot in thickness, the layers being separated by seams of clay or of friable limestone.

Suttee. This word, more correctly written sati or satee, is akin to the Sanscrit SACTI, the term applied to the female power in nature. This power could be approached only after purification, and various rites of this nature were in process of time denoted by this word, which was especially used by the Brahmins to signify the self-immolation of widows on the funeral pile of their husbands. The justification for this practice, and the obligatory precept on which it rested, was found by them in a passage of the Rig Veda, which, as translated by Colebrooke, runs thus: 'Om! let these women, not to be widowed, good wives adorned with collyrium, holding clarified butter, consign themselves to the fire. Immortal, not childless, not husbandless, well adorned with gems, let them pass into the fire whose original element is water.' This passage, Professor Max Müller asserts (*Comparative Mythology*, 23), has been corrupted and falsified by the Brahmans to support their cruel tenet. The real meaning of the verse, in his judgment, is the following: 'May these women who are not widows, but have good husbands, draw near with oil and butter. Those who are mothers may go up first to the altar, without tears, without sorrow, but decked with fine jewels.' The verse is thus addressed, not to the widows, but to the other women, who have to pour oil and butter on the pile; while in a subsequent verse the widow is ordered to leave her husband and return to the world of living men. 'Rise up, woman, come to the world of life; thou sleepest nigh unto him whose life is gone. Come to us. Thou hast thus fulfilled thy duties of a wife to the husband who once took thy hand and made thee mother.'

The injunction to self-immolation, thus obtained by changing the words *yonim agre* into *yonim agneh* (the womb of fire), Prof. Max Müller stigmatises as 'perhaps the most flagrant instance of what can be done by an unscrupulous priesthood. Here have thousands and thousands of lives been sacrificed, and a fanatical rebellion been threatened, on the authority of a passage which was mangled, mistranslated, and misapplied.' He urges, further, that the existence of the word *vidhavâ* (widow) suffices of itself to prove that this practice of self-immolation is comparatively modern. 'If this custom had existed, the want of having a name for widow would hardly have been felt, or if it had been, the word would most likely have had some reference to this awful rite.' But in Sanscrit *dhava* is *a man*, and from this word by the prefix of the preposition *vi*, without, is formed *vidhavâ*, husbandless; and 'if the custom of widow-burning had existed at that early period, there would have been no vidhavâs, no husbandless women, because they would all have followed their husbands into death.'

If, however, this evidence proves beyond all question that the idea of self-immolation, as incumbent on all widows, was at first unknown, it can scarcely prove the negative, that there were no widows who sacrificed themselves. It is conclusive against the universality or frequency of the custom, but not against the theory of self-immolation. It may further be urged that Professor Max Müller's argument fails altogether to account for the origin of the practice, except by attributing it to the disinterested cruelty of a sanguinary priesthood. But even if we grant a position from which we may have a natural shrinking, it may fairly be doubted whether the corruption of *agre* into *agneh* would have sufficed to introduce the practice, however powerful might be the priesthood which enjoined it. Such a fraud might convert into a precept of general obligation a practice which had been the privilege or the pride of a few, but it could scarcely have insured the acceptance of a duty, which could on this hypothesis have had for them no meaning and must have appeared the mere arbitrary command of a sacerdotal caste. Hence we must go further, if we wish to account for the origin of the custom; and it has been thought that the later Brahmanic teaching is connected with mythical phrases and legends familiar to some, at least, among the Aryan nations. If the custom was not general, and if at the same time it existed before the corruption of the Vedic text, it would follow that self-immolation was practised on

the death only of kings, chieftains, or great warriors; and if the death of such men was compared, as we know that at certain stages of thought it commonly is, to the putting out of the light of day, to the sinking of the sun into the dark sea, then the analogy of the earthly wife to the bride of the sun might, it is urged, very naturally suggest itself. The forms which this idea assumed in Hellenic and Teutonic mythology have been noticed in the articles MYTHOLOGY, PARIS, and SIGURDR; and it can scarcely be questioned that Œnônê and Brenhyldr are genuine instances of suttee, whether the practice took its rise from mythical phrases and ideas or whether it did not. But, apart from such striking examples, the tone and spirit of innumerable legends pointed to the conclusion that life could have no attraction for the wife of the hero, whose career and death had resembled that of the glorious sun-god. Such a conclusion might long remain a mere idea, while here and there it might be carried out by some whose very heart was broken by their grief; and if during an indefinite period this self-devotion was occasionally permitted in the wives of kings and heroes, there is nothing surprising in the fact that a powerful priesthood succeeded in the sequel in representing the rite of immolation as a duty incumbent on all women who desired to win a pure and unspotted name.

But, whatever may be its origin, it is certain that the custom had under Brahmanic influence become frightfully common. The English government in the territories under its sway interfered at first only to insure, as far as possible, that the sacrifice should be strictly voluntary on the part of the widow. The presence of a government officer for this purpose imparted to the custom an air of legality which was far from promoting the object of such interference. At length, in December 1829, the rite was abolished in the British dominions by Lord William Bentinck. (Forbes, *Oriental Memoirs* ii. 26; Heber, *Journal* i. 70; Crawford, *Indian Archipelago* vi. 2.)

Sutural (Lat. sutura, *a seam*). In Botany, this term is applied to parts which bear some definite relation to a suture or line of junction between the different parts. Thus, the term *sutural dehiscence* means that a seed-vessel splits along the line of junction of two valves.

Suture (Lat. sutura, *a seam*). In Anatomy, the junction of bones by their serrated or toothed margins: the bones of the skull are so united.

SUTURE. In Entomology, the line at which the elytra meet, and are sometimes confluent.

SUTURE. In Mammalogy, the line formed by the incumbent ends of converging series of hairs of the integument.

Svanbergite. A pale-red mineral found at Wermland in Sweden; and chiefly composed of sulphuric acid, phosphoric acid, alumina, lime, soda, and water. The name Svanbergite has also been applied to Platiniridium.

Swab (A.-Sax. swebban, *to sweep*). A bundle of yarns tied together to form a sort of mop used in drying the decks of a ship.

Swallow (A.-Sax. swalewe, Ger. schwalbe). A name equivalent to the subgeneric term *Hirundo*, appropriated in Modern Ornithology to the British species called *bank*, *chimney*, and *window swallow*, and to foreign allied forms dismembered from the swifts.

Swamp (A.-Sax. swam, Dan. svamp). Ground habitually so moist and soft as not to admit of being trod on by cattle, but, at the same time, producing particular kinds of trees, bushes, and plants. A swamp differs from a bog and a marsh in producing trees and shrubs, while the latter produces only herbage plants and mosses.

Swamp-ore or **Swampy Iron-ore.** An old name for BOG IRON-ORE.

Swan (Ger. schwan, Dan. svane). Of the noble web-footed birds so called there are three British species—the Hooper, or Bewick's, the wild, and the tame swan. These form the type of the subgenus *Cygnus*. The wild swan and Hooper ought perhaps to be regarded as the only true native species. The tame swan (*Cygnus olor*) is superior in bulk to either of the wild species, and is at once distinguished by a large black callous knob on the base of the bill. Both the wild species are peculiarly characterised by convolutions of the windpipe, extending in the mature bird through the whole length of the keel of the sternum. These convolutions are horizontal in the *Cygnus Bewickii*, and vertical in the *Cygnus ferus*.

Swanhild. In Teutonic Mythology. [SIGURDR.]

Sward. Green turf; i.e. the surface of land under pasture grasses. A fine sward may be called the characteristic feature of British landscape, not being found in the same degree of perfection in any other country, not even in Ireland.

Swash Letters. In Printing, letters which had their terminations projecting considerably beyond the shank thus: K Q R &c. They have been revived of late years with the re-introduced old-fashioned types.

Sweating Sickness. An epidemic of great severity which appeared in England at different periods towards the end of the fifteenth and beginning of the sixteenth century. It is generally believed to have broken out in the army of the duke of Richmond, afterwards Henry VII., on his landing at Milford Haven. It spread over various neighbouring countries, and was called *sudor Anglicus*. Curiously enough, it mostly attacked persons of rank, and those in good health. The disease may be described as a fever commencing with heat in some one limb or in some part of the body, spreading over the whole surface, and followed by profuse and exhausting sweating, with insatiable thirst. Restlessness, nausea, delirium, and headache, with irregular action of the heart, were always present. Patients often died in from two to four hours after the sweat set in.

The last visitation of the scourge in England was in 1551. [PLAGUE.]

Swede. A kind of Turnip with yellow flesh, introduced from Sweden, much cultivated as a root crop by agriculturists. Its botanical name is *Brassica campestris rutabaga.*

Swedenborgians. Those persons who on religious subjects receive the testimony of Swedenborg, a Swedish nobleman who died in 1772. In his work entitled *Arcana Cœlestia*, and in his *Apocalypsis Revelata*, Swedenborg professes to make known what he calls the Science of Correspondences, or that analogy between spiritual and natural things, according to which, he says, the Word of God is written. Thus, Jerusalem signifies not only the chief city of Palestine, but the Lord's church, and more specifically the religious doctrines by which persons are united into a church. Hence the new Jerusalem, seen by John descending from God out of heaven, signifies a new church, or a new developement of pure doctrines from the Holy Word, which will eventually regenerate the world. In these doctrines may be considered as most prominent the acknowledgment of the Lord Jesus Christ as the one God in whom is centred the Divine Trinity, and the necessity for uniting charity with faith, or, in other words, for the keeping of the divine commandments, in which is included the performance of every duty. The admirers of Swedenborg, who form a separate religious body, which they denominate the New Church, have places of worship in London and other towns of England, and are greatly increasing in America. In the religious census of 1851 the number of their congregations in England is stated at fifty.

Sweeps. Very long oars used occasionally in the bows of ships to assist the action of the rudder during a calm.

Sweet Bay. Another name for the Noble Bay, *Laurus nobilis.* [LAURUS.] In America, the name is applied to *Magnolia glauca.*

Sweet Flag. The *Acorus Calamus*, an aromatic native plant found in moist situations in this country. [ACORUS.]

Sweet Sop. The fruits of *Anona squamosa* and *A. sericea.*

Sweetbread. The thymus gland of the calf is employed as food, under this name; it contains about seventy parts of water, and thirty of nutritious matter, chiefly of an albuminous character. 'A fresh sweetbread when plainly cooked (by boiling) and moderately seasoned, forms a very agreeable and suitable dish for the convalescent; but, when highly dressed, is improper both for dyspeptics and invalids. (Pereira *On Diet.*)

Swell (a Teutonic word). In Music, a part of an organ. It consists of a small separate organ enclosed in a box, the whole being contained within the case of the large instrument. The box has shutters or louvre boards which can be opened or shut by means of a pedal, so as to allow the sound of the pipes within either to be heard distinctly or partly suppressed at the pleasure of the player, and thus to produce a swelling effect, whence the name.

Swell of the Muzzle. [GUN.]

Swietenia (after Baron von Swieten, a Dutch botanist). *Swietenia Mahagoni*, the tree which yields the Mahogany of commerce, is the sole representative of this genus of *Cedrelaceæ*, and is peculiar to the warmer parts of America and the West Indies. It forms a stately tree of some sixty or eighty feet high. The first discovery of the beauty of mahogany wood is attributed to the carpenter on board Sir Walter Raleigh's ship, while lying off Trinidad in 1595. At Honduras the wood is not considered to be in perfection when under 200 years old. The bark is considered a febrifuge, and the seeds prepared with oil were used by the ancient Aztecs, as they are by the modern Mexicans, as a cosmetic.

Swimmers (a Teutonic word). The web-footed or aquatic birds (*Natatores*, Ill.; *Palmipedes*, Cuv.) are so called; also a tribe of spiders (*Araneidæ natantes*) which live in water, and there spin and spread abroad filaments to entrap their prey.

Swimming. Amongst land-mammals, man seems to be the only one without the natural faculty of swimming. It is acquired by practice, imitation, or being taught. The learner, immersed to the neck, is directed to begin by placing the palms of the hands together and pushing them forward about an inch under water, the knees at the same time being drawn up under the body, as if preparing for a spring. The next movement is that of divarication of the hands, in the form of a scoop, the fingers being kept close and the thumb downward, so as to thrust back the water with a wide sweep of the entire arm from the shoulder. At the same moment the legs are thrown back, the feet pushing away the water beneath, the effort being that of making a spring forward. When the arms have made their utmost horizontal extension, they are to be bent with the elbows drawn back until the ball of the thumb of each hand gently touches the ribs; the palms, being then again brought together, are pushed forward in a direct line (the tips of the two thumbs passing under the chin) to repeat the stroke. In like manner, the motion of the legs and feet having been made, the action is relaxed, and the legs stretched out with the toes inclined downward till the knees are again drawn up to repeat the stroke. The principal propelling power is in the legs, the arms and hands acting chiefly in bearing up the head above the surface. It is essential that the action of arms and legs be simultaneous. Man thus most closely imitates the swimming of the frog.

To one in danger of drowning, it is more important to know how to *float* than how to *swim*. The exercise of the muscles in a good swimmer necessitates more frequent respiration, and exhausts the strength. If a shore be within reach and no help nigh, the swimmer may, indeed, save himself, when the floater

would, at ebb-tide, be carried out. But in the majority of instances, where the life of the immersed depends on human help, the longer the body can be kept afloat the greater the chance of rescue. The specific gravity of the body with the lungs moderately distended with air is less than that of water, especially of sea water. The brain will help to float the skull if it be immersed. The main point is to keep as much of the body under water as may be: only occasional emersion of nose and mouth is essential to breathing. If, on immersion, the chest be well filled with air, and no struggling or act of expiration takes place, the body will rise to the surface, and if the head be then kept well back or down in the water, the nose and mouth will emerge. Then let the floater breathe, expiration by the nostrils being instantly followed by drawing in at the mouth as much air as can be taken. All the part of the head containing the brain should be kept well under water; not a finger or any part of the limbs should be lifted out of water: it would add so much to the sinking weight. A slight extension of the arms under water, with the palms horizontal and gently beating down the water like fins, will help to maintain the prone position of the body.

Swimming Stone. A name sometimes given to the spongy kind of Quartz called FLOAT-STONE.

Swine. [SUS.]

Swine Pox. [CHICKEN POX.]

Swine Stone. [STINK STONE.]

Swing (a Teutonic word). A ship at anchor is said to swing when she changes her position at the turn of the tide.

Switches. [RAILROADS.]

Swivel Gun. In Artillery, a gun fixed on a *swivel*, by means of which it may be directed to any object. Swivel guns are used chiefly at sea.

Sword (a Teutonic word). A weapon of offence used from the earliest historical times, now employed chiefly for cavalry. The knightly sword of the middle ages was broad, straight, two-edged, and acutely pointed with a simple cross piece for its guard. In the sixteenth century, various forms of guards and hilts appeared. The sword for all cavalry in our service, except the household troops, has a blade slightly curved, and 3 ft. 4 in. long, with a handle 5½ in. long. It weighs 2 lbs. 1 oz.

Sword, Order of the. A Swedish military order of knighthood, instituted by Gustavus Vasa.

Sword of State. Four swords are used at the coronation of a British sovereign: 1. The sword of state properly so called. 2. The curtana (curtus, *shortened*), the sword of mercy, which is pointless: it is mentioned by Matthew Paris. 3. The sword of spiritual justice. 4. The sword of temporal justice. These three are carried before the sovereign: he is girt with the first.

Sybarite. A term used metaphorically to designate an effeminate voluptuary; so called from the inhabitants of Sybaris, formerly a town of Italy on the gulf of Tarentum, who were said to have been so enfeebled by sensual indulgence that they became an easy prey to the Crotonians, a people comparatively insignificant in point of numbers, by whom their city was levelled to the ground, B.C. 310.

Sycamore. A hardy ornamental deciduous tree belonging to the Maple family, known by its five-lobed leaves, and its profusion of flat winged twin fruits, popularly called *keys*, and distinguished by the scientific name *Acer Pseudo-Platanus*. This tree is to be distinguished from the Sycomore of the Bible (Luke xix.), which is a species of fig, though probably the name originated in some confusion of ideas as to the identity of both. Indeed, in old books what is now universally called *sycamore* was sometimes written *sycomore*, while the sycomore fig is in some modern versions of the Bible printed *sycamore*. [SYCOMORE.]

Sycee (Chinese sai-sz', *fine silk*). A term, used to denote the fine silver of China, also called *wanyin*, or pure silver. The only currency, in the proper sense of the word, issued by the Chinese government is that of a mixed metal, the coins of which, called *cash*, are strung by means of a square hole passed through the centre of the coin. Ten of these make a *candareen*, ten candareens a *mace*, ten mace a *tael*. Only the cash, however, is coined, with the exception of a depreciated piece, nominally of ten cash, which has a forced circulation within the walls of Pekin. These terms are foreign, the Chinese names being, *li*, *fan*, *tsien*, and *liang*. The cash, by an edict of 1644, was made of seven parts copper and three zinc. But at present a considerable alloy of tin is substituted for the copper, and even lead, iron, and sand are added fraudulently in the provincial mints. The coins are cast.

But the taxes are paid in silver, generally of the purest kind, and known among bankers by the name of *sycee*. This silver is cast into ingots, sometimes small, and weighing little more than 175 grains troy, sometimes so large as to weigh upwards of 5 lbs. troy. The most common weight is rather more than a pound troy. The ingots bear a rough resemblance to a Chinese shoe, and are therefore called *shoes* by foreigners. The fineness of the silver is known by the number of *touches* which it is said to contain; thus *sycee of* 99 *touch* means that the ingot has only one part in a hundred of alloy. The ingots are stamped with the seals of the assayer or banker in evidence of their purity.

The silver currency of the mercantile public, and to some extent of the natives, is derived from foreign dollars. These coins are not, except on rare occasions, and by special proclamation (*Accounts and Papers* 1857-8, vol. xliii.), recognised by the Chinese government. Formerly the Spanish pillar dollar was in great request; at present, the Mexican dollar is current and in the highest favour. The singular circumstance that the Chinese government does not coin silver, and receives its taxes

by weight of fine bullion, is to be explained by the fact that its authority is wholly inadequate to secure the weight and fineness of an internal currency by any mint regulations or police. The public servants are corrupt; and, to judge from some acts of the government, it is not likely that it would preserve the standard which it might at first issue. But the Chinese people, and especially the mercantile classes, are far too astute to be defrauded, and the latter part of the community derive a considerable profit from bullion operations.

It was suggested by Sir John Bowring, that the English government should establish a mint, and coin their own dollars, at Hong-Kong; but the Foreign Office, knowing the great dislike of the Chinese to innovation, did not at first venture on the expense of setting up a mint. Latterly, however, coins, a silver dollar and a half-dollar of nine-tenths fineness, with another coinage in silver of eight-tenths fineness, containing 20, 10, and 5 cent pieces, and also a bronze cent and a bronze mil, have been struck. Some of these coins, though issued at Hong Kong, were struck at Birmingham. These coins, however, are considerably below the standard of sycee.

Sycoma (Gr. σύκωμα, from σῦκον, *a fig*). A fig-shaped excrescence or warty tumour.

Sycomore (Gr. συκόμορος). The sycomore of the Bible is the *Ficus Sycomorus* of the older botanists, but according to more modern views is now sometimes called *Sycomorus antiquorum*. It is a large tree with a thick trunk, out of which, as well as from the larger branches, the fruits issue. These are shaped like the common fig, and have a sweet and delicate taste. The tree is also called Pharaoh's Fig-tree. It is quite distinct from the tree called SYCAMORE.

Syconium (Gr. σῦκον, *a fig*). In Botany, the name applied to such fruits as that of the fig, consisting of a fleshy receptacle loaded with flowers, each producing its own proper seed-vessel.

Syconus. [SYCONIUM.]

Sycophant (Gr. συκοφάντης, from σῦκον, and φαίνω, *I disclose*). It was forbidden by the laws of Athens at one period to export figs. The public informers who gave notice of delinquencies against this fiscal law were extremely unpopular, and hence the word came into use to signify an informer or false accuser generally; in which sense it is constantly used by Aristophanes and the orators. In modern usage it has acquired the sense of a mean flatterer.

Sycosis (Gr. σύκωσις). A tubercular eruption upon the scalp, or bearded part of the face: it sometimes forms a very troublesome impediment to shaving.

Syenite. A granitic aggregate of quartz, felspar, and hornblende, from Syene in Egypt, whence the Romans obtained it for architectural purposes. [GEOLOGY.]

Syepoorite. A sulphide of cobalt, of a steel-colour inclining to yellow, which occurs in grains or veins in primary schist, mechanically mixed with Magnetic Pyrites, at Saipoor, near Rajpootana in North-Western India. It is said to be used by the Indian jewellers to give a rose-colour to gold.

Syllable (Gr. συλλαβή). A syllable, as defined by Girard, is a simple or compound sound, pronounced with all its articulations by a single impulsion of the voice. The principal difficulty in arranging the syllabic construction of language is to ascertain in what cases two or more consonants following each other may be joined in a syllable; which can only be done by an investigation of the mechanism of speech. (Max Müller's *Lectures on Language*, second series, iii.)

Syllabus (Gr. σύλλαβος). A compendium or abridgment, or a table of contents; as a syllabus of lectures, &c.

Syllepsis (Gr. σύλληψις, *a taking together*). A name given by some writers to that idiom of the Greek and Latin languages whereby an adjective predicated of a masculine and feminine substantive is made to accord in gender with the former: e.g. *rex et regina beati*.

Syllogism (Gr. συλλογισμός, *a gathering together*). According to the scholastic system of Logic, adopted by Archbishop Whately, the syllogism is an argument stated in the form of three propositions, having the property that the conclusion follows necessarily from the two premisses, so that, if the premisses be true, the conclusion must be true also. In such arguments the conclusion is contained in the premisses, so that nothing more can be inferred in the third or concluding proposition than is involved in the two which precede it. To this theory of syllogism many objections have been made, some of which are noticed in the article LOGIC; but we think it right to give, without any running comment, a sketch of Dr. Whately's system, reserving for the close of the article a few remarks on some of the difficulties involved in it.

According to this system, as often as the mind observes any two notions to agree with a third, it immediately concludes that they agree with each other: as, A is equal to B; B is equal to C; therefore A is equal to C. Or, if it finds that one of them agrees and the other disagrees with the third, it pronounces that they disagree with each other. In the first of these processes it produces a syllogism with an affirmative conclusion; in the latter, a syllogism with a negative conclusion.

Syllogisms are variously divided: by some into *single*, *complex*, and *conjunctive*, &c.; by others (according to the Oxford system of logic) into *categorical*, *hypothetical*, *conditional*, &c. But the categorical syllogism, consisting of three categorical propositions, is the simplest form, and that to which all other forms can be reduced.

The following are the two canons by which the validity of a categorical syllogism is explained: 1. If two terms, i.e. notions expressed in language [TERM], agree with one and the same third, they agree with each other. 2. If

one term agrees and another disagrees with a third, the first two disagree with one another. Hence are deduced the six following rules:—

1. Every syllogism has three terms only: viz. the middle term, and the two extremes. The subject of the conclusion is called the *minor term*; its predicate, the *major term*: the *middle term* is that with which they are respectively compared. 2. Every syllogism has three propositions only: the *major premiss*, in which the major term is compared with the middle; the *minor premiss*, in which the minor term is compared with the middle; the *conclusion*, in which the major and minor terms are compared together. 3. The middle term must be, in logical language, distributed once at least in the premisses; i.e. it must be the subject of a universal, or the predicate of a negative; otherwise it may happen that one of the extremes is compared with one part of it, and the other with another part. 4. No term must be distributed in the conclusion which is not distributed in one of the premisses; otherwise the whole term would be employed in the conclusion, where part only is employed in the premiss: this error is called an *illicit process* of the major or minor premiss. 5. From negative premisses we can infer nothing; i.e. if two terms disagree with a third, we cannot infer either their mutual agreement or disagreement. 6. If one premiss be negative, the conclusion must be negative; for if one term disagree with the middle, it must of necessity also disagree with the other. The other rules are corollaries deducible from these six.

The *mood* of a syllogism is the designation of its three propositions in their order, according to their respective quantity and quality. By reference to the head PROPOSITION, it will be seen that arbitrary symbols are adopted in logic to mark the quality and quantity of propositions; thus, A stands for a universal affirmative; E represents a universal negative; I a particular affirmative; O a particular negative. These four letters will afford sixty-four different combinations of three letters; but of these the greater part will afford syllogisms erring against some one or more of the rules previously laid down; thus EEE would be at once inadmissible, as exhibiting two negative premisses—against rule 5. By an accurate examination, it is found that eleven moods only will afford correct syllogisms: AAA, AAI, AEE, AEO, AII, AOO, EAE, EAO, EIO, IAI, OAO.

The *figure* of a syllogism consists in the situation of the middle term with reference to the major and minor terms. 1. The first figure is where the middle term is the subject of the major premiss, and predicate of the minor. 2. Where the middle term is the predicate of both premisses. 3. Where it is the subject of both. 4. Where it is the predicate of the major and subject of the minor. Multiplying the moods by the figures, we should have forty-four different syllogisms. But it will be found, on examination, that five moods in each figure (twenty in all) would err against some one or other of the rules before laid down: e.g. AII is an allowable mood in the third figure; but, in the first, it would have an undistributed middle. Of the twenty-four remaining, five are unnecessary; i.e. they are moods in which a particular conclusion only is inferred from premisses which would warrant a universal. The nineteen remaining are expressed in the following mnemonic lines:—

Fig. 1. 4 moods: BA*r*b*A*r*A*, *c*E*l*A*r*E*nt*, *d*A*r*II, *f*E*r* IO*que*, prioris.
Fig. 2. 4 moods: CE*s*A*r*E, *c*A*m*E*str*E*s*, *f*E*st*-I*n*O, *b*A*r*O*k*O, secundæ.
Fig. 3. 6 moods: Tertia *d*A*r*A*pt*I, *d*I*s*A*m*I*s*, *d*A*t*I*s*I, *f*E*l*A*pt*O*n*, BO*k*A*rd*O, *f*E*r*I*s*O*n*, habet: quarta insuper addit.
Fig. 4. 5 moods: B*r*A*m*A*nt*I*p*, *c*A*m*E*n*E*s*, *d*I*m*A*r*I*s*, *f*E*s*A*p*O, *fr*E*s*I*s*O*n*.

One mood in each figure may be given by way of example. The letter M designates the middle term; the letter preceding the proposition, its quantity and quality.

1. A. All excess (M) is sinful.
   A. All gluttony is excess (M): therefore,
   A. All gluttony is sinful. (A syllogism in Barbara.)

2. A. Everything expedient is lawful (M).
   E. Nothing unjust is lawful (M): therefore,
   E. Nothing unjust is expedient. (A syllogism in Camestres.)

3. A. All conquerors (M) are cruel.
   I. Some conquerors (M) are just: therefore,
   I. Some just men are cruel. (A syllogism in Datisi.)

4. A. Whatever is expedient is conformable to nature (M).
   E. Whatever is conformable to nature (M) is not hurtful: therefore,
   E. What is hurtful is not expedient. (A syllogism in Camenes.)

It will be observed that in all these instances the major premiss is presumed to precede the minor; but although this is the most convenient form of reasoning, the minor premiss is, with equal validity, made the first in the series: e.g.

> Brutus is an honourable man:
> Honourable men affirm the truth; therefore,
> Brutus affirms the truth.

This is a syllogism in Barbara, with the minor premiss placed before the major.

The fourth figure is considered to be inverted and unnatural; and the first three figures with their fourteen moods furnish almost every argument which is employed, however far it may be removed in appearance, through the intricacy of language, from the syllogistic form. But all arguments may be brought, by an ingenious process termed *reduction*, into one or other of the four moods of the first figure.

In reducing a syllogism, the premisses may be illatively converted [ILLATIVE CONVERSION] or transposed; since the force of the argument can be altered by neither of these processes.

By this process, we deduce either the same conclusion with the original, or another conclusion from which the original conclusion follows by illative conversion. We have not space to explain, by examples, these various processes. The letters which compose the names of the syllogistic moods are framed to express the manner in which those of the three last figures are reduced into those of the first. The first letter indicates the mood into which those beginning with the same letter are to be reduced: e.g. Bramantip is reducible into Barbara; *m* indicates that the premisses are to be transposed; *s* and *p* that the proposition denoted by the vowel immediately preceding is to be converted—*s* simply, *p* per accidens; *k*, which occurs only in Baroko and Bokardo, indicates that the proposition denoted by the vowel immediately before it must be left out, and the CONTRADICTORY of the conclusion substituted, which is termed the *reductio ad impossibile*.

A hypothetical syllogism is one in which the conclusion is deduced from an hypothetical premiss (called the *major*) and a categorical premiss (called the *minor*). It is of two kinds—conditional and disjunctive; the first subdivided into constructive and destructive.

1. Conditional constructive.	If the demand increases, the supply will increase: But the demand increases; Therefore the supply will increase.
2. Conditional destructive.	If the country is flourishing, agriculture is flourishing: But agriculture is not flourishing; Therefore the country is not flourishing.
3. Disjunctive.	Either A is B, or C is D: But A is not B; Therefore C is D.

It is evident that a disjunctive syllogism may easily be reduced to a conditional. (See the *Compendium of Logic*, by Dean Aldrich, commonly used at Oxford; and the Treatise of Archbishop Whately.)

To the foregoing theory of the syllogism, the chief objection made is that the reasoning process is made to rest wholly on the Aristotelian dictum *de omni et nullo*, an axiom which possesses value and is really intelligible only with a realistic philosophy. It will be readily admitted that nothing is gained or learnt by referring any object to a mere *name* which has been obtained by a comparison of other objects of the same nature. So long as it was supposed that *humanity* was an entity existing apart from all the individual men who have ever lived or may live, the predication, in the case of a given individual, of any quality belonging to this substantia secunda was the assertion of a fact which might be new, and which certainly was important. But when it is maintained that *humanity* is a mere arbitrary name or label under which are grouped certain phenomena which bear a certain resemblance to each other, the dictum of Aristotle is reduced to the identical affirmation that whatever is true of any given number of objects is true of each of those objects, a proposition which cannot be disputed, but which may be dismissed as fruitless and dead. Hence it follows that the syllogism, so long as it is confined strictly within the limits of the scholastic logic, cannot possibly be made a means for the discovery of new truth, and remains at best an instrument for the exercise of mental ingenuity. When we say that all men are mortal, and that Cæsar is mortal because he is a man, we do not really infer the mortality of Cæsar before he is really dead, from the generalisation that all men are mortal. This generalisation was in the first instance obtained only by an observation of individual instances; and when it was found that certain individuals with special points of resemblance or difference resembled each other in undergoing a change called *death*, this result of strict induction was registered in a useful general proposition asserting the mortality of all men or of all animals or of all living organisms.

Thus the province of the scholastic syllogism is reduced to a very narrow compass. It will enable us to test the correctness of our generalisations, but it cannot enable us to arrive at new generalisations; in other words, it cannot add to our stock of the knowledge of phenomena. It is a touchstone for ascertaining the value or the genuineness of treasures already gained, but not an instrument for the discovery of further treasures of which we are in search.

It is further objected that, as all knowledge is gained by induction, and as propositions are concerned not with names but with things or facts, the method which deals with propositions by substituting arbitrary signs as the subject and predicate, and thus makes the validity of the syllogism to depend upon its form is, to say the least, deceptive and dangerous. The system, which makes all reasoning to consist in the observation of phenomena, in the accurate colligation of facts, and the exact ascertainment of their several points of agreement and difference, leaves no room for the notion that the validity of an argument is manifest from the mere form of expression without reference to the meaning of the words employed, i. e. without regard to the things or facts which the words or signs are used to denote. That this notion, although frequently stated without qualification, is really set forth with considerable reserve, is apparent as soon as we proceed to carry it out to its full limits. The assertion, that every argument thrown into the form,

Every A is B; every C is A:
therefore every C is B,

is valid, resolves itself into an absurdity, if for A we substitute *philosophers*, for B *quadrupeds*, and for C *peacocks*. Hence the whole doctrine of moods and figures really requires that in every single case the general proposition shall be in accordance with facts; in other words, that it shall be an accurate induction from the observation of phenomena, while the minor premiss shall state some point of agreement or

difference which has been ascertained by actual search, and is not merely a figment of our imagination. Thus, the form of the syllogism, of itself, proves nothing: and an argument formally correct may be absolutely worthless. Apart from the inductive or experimental examination of phenomena there can, it would follow, be no reasoning and no logic.

The doctrine that no conclusion can be drawn from two particular propositions, is, it is urged, not strictly correct. If the two propositions are severally in accordance with fact, they may form part of an inductive process and carry us over an important stage of our journey, but in any case they must involve some direct conclusion. If we are told that butterflies are not *Hemiptera*, and that bees are not *Hemiptera*, from these two particular propositions (far from drawing no conclusion) we learn that there are two classes of insects which do not belong to the class *Hemiptera*; and at once we see that conclusions drawn from such particular propositions are among the most important in the processes of logic.

Exception has, likewise, been taken to the classification of syllogisms according to the affirmative or negative character of propositions, and to the CONVERSION of syllogisms from one figure to another. Against the former it is urged that all negative propositions may be thrown into an affirmative form by altering the expressions without changing the meaning, and against the latter that the several moods of the second, third, and fouth figures are only modifications of arguments which may be cast into the form of the first. These objections resolve themselves into the assertion that propositions are concerned not with names or notions, but with things or facts: and it is unnecessary to discuss them at length, so long as it is remembered that all generalisations are mere tickets or labels, serving to preserve arrangements of recorded and observed phenomena, and that in the processes of induction fresh knowledge is gained by reasoning not from universals, but from particulars to particulars.

Sylph (Gr. σίλφη, *a kind of insect*). The name given to the spirits of air in the fantastic nomenclature of the ROSICRUCIANS and Cabalists. [CABALA.] The use which Pope has made of this fancy in his *Rape of the Lock* is well known. He seems to have borrowed it from the enigmatical romance called the *Count de Gabalis*.

Sylvanite. A name given originally to native Tellurium, from its being discovered first in Transylvania.

Sylvine. Native chloride of potassium, found with Common Salt at the mines of Hallein in Salzburg, and Berchtesgaden in Bavaria; also sublimed about the fumaroles of Vesuvius. The name Sylvine has reference to the *digestive salt* of Sylvius de la Boë, with which it is identical.

Symbol (Gr. σύμβολον; from σύν, *together*, and βάλλω, *I throw*). A word of many meanings, although now commonly used in one only. 1. The primary meaning of the verb συμβάλλειν expresses the act of several in constituting or throwing together portions to form a whole. Hence σύμβολον signified a treaty or agreement. (Arist. *Polit.*) It seems to be in this sense that the creeds are termed by early ecclesiastical writers *symbols*: either because (as Augustine says) all the fundamental doctrines of Christianity are *collected* in them; or from the old traditionary story, related by Rufinus, that the creed called the Apostles' Creed was formed by each of them contributing a sentence. [CREED.] 2. The mind may be said to put together outward appearances, and collect from them the notion of a thing signified by them; and hence the outward appearances themselves may be called *symbols*, signs, or emblems; while the act of the mind is termed *conjecture* (Lat. conjicio). Thus, the standards of military bodies were called by the Greeks *symbols*; as likewise omens and portents; and expressions or figures denoting a received meaning, as the Pythagorean symbols. In this sense, the early Christians gave the general name of *symbols* to all rites, ceremonies, and outward forms bearing a religious meaning, to the sacraments and the sacramental elements, to the cross, and, in later times, to images and pictures. Symbols, properly so called, must be distinguished from TYPES, and from mere symbolical attributes, such as the figures usually introduced in representations of the four Evangelists. *Symbolical books* are such books as contain the creeds and confessions of different churches: as the three creeds, received by all; the Confession of Augsburg, received by the Lutherans; the articles of the church of England, &c. The Germans call the study of the symbols and mysterious rites of antiquity, and also the study of the history and contents of Christian creeds and confessions of faith, by the name of *symbolics* (mythological or theological). Marheineke's *Institutiones Symbolicæ*, of which the first edition appeared in 1812, is one of their most distinguished works in the latter class.

Symbols. In Mathematics, certain marks by which numbers, quantities, or operations are represented. [NOTATION, MATHEMATICAL.] By a *calculus of symbols* is meant a systematic method of combining symbols according to prescribed laws. [OPERATIONS, CALCULUS OF.] *Symbolic algebra* is that branch of the general calculus of symbols where algebraic symbols and operative rules are considered. (De Morgan's *Double Algebra.*) *Symbolic geometry*, again, is a science wherein the symbols have geometric meanings, and the operations a geometrical character. [QUATERNIONS.] Great progress has recently been made, and especially in England, in the developement of symbolical methods. Recent volumes of the transactions of our learned societies and of our mathematical journals contain valuable papers on the subject by several writers, amongst whom may be mentioned Gregory, Warren, Peacock, Sir W. R. Hamilton, De Morgan, Cayley, Sylvester,

Boole, Hargreaves, Donkin, Carmichael, Spottiswoode, Russell, &c.

Symbols, Botanical. In their descriptions of plants, botanists use certain signs or abbreviations to convey information in the most ready way on certain general facts which have to be recorded, or to express particular attributes in the subject under description. The signs or symbols in most frequent use are the following:—

♂ = male.
♀ = female.
☿ = hermaphrodite, or bisexual.
♂-☿-♀ = polygamous.
♂ ♀ = diœcious.
- ♀ = monœcious.
♂-☿-♀ = triœcious.
① or ○ = annual.
② or ♂ = biennial.
♃ = perennial.
♄ = a tree or shrub.
∞ = an indefinite and considerable number of anything.

! placed after a person's name indicates that an authentic specimen from that person has been seen.

* at the end of a citation denotes that a plant is fully described in the place referred to.

v.v. = seen alive.
v.s. = seen in a dried state.
v.c. = seen cultivated.
v.sp. = seen wild.

′ ″ ‴ When these signs are placed after a number, they express a foot, an inch, or a line respectively; thus, 5′ = 5 feet; 5″ = 5 inches; 5‴ = 5 lines.

A very full account of all such signs is given in the fourth edition of Lindley's *Introduction to Botany*, ii. 384.

Symbols, Chemical. A chemical symbol is the representation of one atom or combining proportion of each elementary substance by the capital initial letter of its Latin name, it being necessary where the names of two or more elements begin with the same letter to add a second, in a smaller character, for the purpose of distinguishing between them. Thus C, Cl, Ca, Cd, Co, Cu, Ce, Cr, are the symbols of Carbon, Chlorine, Calcium, Cadmium, Cobalt, Copper (Cuprum), Cerium, and Chromium; H and Hg are the symbols of Hydrogen and of Mercury (Hydrargyrum); O and Os of Oxygen and of Osmium; and so on. The following table enumerates, in alphabetical order, the simple or elementary substances, with their annexed symbols and atomic weights; i.e. the respective *weights* of each of the elementary bodies which each symbol represents upon the *hydrogen* scale, or in reference to hydrogen as unity:—

	Atomic weight. Old notation.	Atomic weight. New notation.	Symbol.
Aluminum	13·8	27·5	Al.
Antimony (Stibium)	122	122	Sb.
Arsenic	75	75	As.
Barium	68·5	137	Ba.
Bismuth	208	208	Bi.
Boron	11	11	B.
Bromine	80	80	Br.
Cadmium	56	112	Cd.
Cæsium	133	133	Cæ.
Calcium	20	40	Ca.
Carbon	6	12	C.
Cerium	46	92	Ce.
Chlorine	35·5	35·5	Cl.
Chromium	26	52·5	Cr.
Cobalt	29·4	58·8	Co.
Copper (Cuprum)	31·7	63·5	Cu.
Didymium	48	96	Di.
Fluorine	19	19	F.
Glucinum	7	14	G.
Gold	196·7	196·7	Au.
Hydrogen	1	1	H.
Iodine	127	127	I.
Iridium	99	198	Ir.
Iron (Ferrum)	28	56	Fe.
Lanthanum	46	92	Ln.
Lead (Plumbum)	103·5	207	Pb.
Lithium	7	7	Li.
Magnesium	12	24	Mg.
Manganese	27·5	55	Mn.
Mercury (Hydrargyrum)	100	200	Hg.
Molybdenum	46	92	Mo.
Nickel	29·4	58·8	Ni.
Niobium	48·8	97·6	Nb.
Nitrogen	14	14	N.
Osmium	99·5	199	Os.
Oxygen	8	16	O.
Palladium	53·2	106·5	Pd.
Phosphorus	31	31	P.
Platinum	98·7	197·4	Pt.
Potassium (Kalium)	39	39	K.
Rhodium	52	104	Ro.
Rubidium	85·5	85·5	Rb.
Ruthenium	52	104	Ru.
Selenium	39·5	79	Se.
Silicon	28·5	28·5	Si.
Silver (Argentum)	108	108	Ag.
Sodium (Natrium)	23	23	Na.
Strontium	43·7	87·5	Sr.
Sulphur	16	32	S.
Tantalum	68·7	137·5	Ta.
Tellurium	64	128	Te.
Thallium	204	204	Tl.
Thorium	115·7	231·5	Th.
Tin (Stannum)	59	118	Sn.
Titanium	25	50	Ti.
Tungsten	92	184	W.
Uranium	60	120	U.
Vanadium	68·5	137	V.
Yttrium	34	68	Y.
Zinc	32·5	65	Zn.
Zirconium	45	90	Zr.

It will be understood that the above symbols represent a single atom of each of the simple bodies, in reference to hydrogen as *unity*. Thus, on the old system of notation H represents 1 part by weight of hydrogen; O, 8 parts by weight of oxygen; S, 16 of sulphur; Hg, 100 of mercury, and so on. It is evident, however, that, as far as these combining proportions are concerned, other numbers or weights, bearing the same relations to each other, might be adopted: thus upon the *oxygen* scale, oxygen is represented as = 100; in which case hydrogen is 12·50, sulphur 200, mercury 1250, &c. But we shall confine ourselves exclusively to the hydrogen scale, which is now in most general use, and is in all respects preferable to the more complicated numbers which the oxygen scale necessarily involves.

When two or more atoms of one elementary substance are to be indicated, figures are placed either before or after the symbol. Thus, 2 atoms of iron may be represented by 2 Fe, or by Fe_2; in the former case a large, in the latter a small numeral being generally adopted. It is customary to place this small numeral

somewhat above or below the symbol, as Fe^2, or Fe_2. For further information on this subject, see NOTATION, CHEMICAL.

Symbols, Zoological. The symbols referring to sex and size are the same as in botany, the former being most commonly used in the description of insects. Those indicative of particular teeth and their arrangement are restricted in use to diphyodont mammals: they consist of the initial letters of the following kinds of teeth: *i.* incisors, *c.* canines, *p.* premolars, *m.* molars. When teeth of these kinds belong to the first or deciduous series, the letter *d* is prefixed: the individual tooth of each kind is indicated by an added numeral. The numbers and relative position of each kind of teeth in any given genus of diphyodont, are indicated by formulæ of the following kind:—

$$d.i.\frac{3-3}{3-3},\ d.c.\frac{1-1}{1-1},\ d.m.\frac{4-4}{4-4} = 32.$$

$$i.\frac{3-3}{3-3},\ c.\frac{1-1}{1-1},\ p.\frac{4-4}{4-4},\ m.\frac{3-3}{3-3} = 44.$$

These show the numbers and kinds of teeth, in both first and second dentitions, of the hog (*Sus*). The kinds of teeth follow each other in the jaw, from before backward, as their symbols are written from left to right; the numerals above the line indicate those of the upper jaw, the numerals below the line those of the lower jaw: the numbers of each kind of teeth, on the right and left sides of both upper and lower jaws, are indicated by the connecting dash. This symbolism or notation shows that the deciduous dentition of the genus *Sus* includes the following teeth on each side of both jaws, viz. three incisors, one canine, and three molars, the total number being thirty-two: the permanent dentition similarly includes three incisors, one canine, four premolars, and three molars, the total number being forty-four. The individual teeth, in each series of several, are symbolised as they follow one another from before backward, the incisors as *i.*1, *i.*2, *i.*3, the premolars as *p.*1, *p.*2, *p.*3, *p.*4, the molars as *m.*1, *m.*2, *m.*3. Each of these teeth in the hog may be distinguished from the rest; and if, among the fossil remains of an extinct species, $m.\overline{3}$ is said to be found, the symbol implies it to be the third or last molar of the upper jaw; $m.\underline{3}$ in like manner symbolises the third molar of the lower jaw, and so of the other symbols of individual teeth according to their relative position, vertically, to the added line. As the first of the four premolars in the hog appears to be the first of the deciduous series unshed, or retained, it may be symbolised as *d.m.*1.

The permanent dental formula of the dog (*Canis*) is:—

$$i.\frac{3-3}{3-3},\ c.\frac{1-1}{1-1},\ p.\frac{4-4}{4-4},\ m.\frac{2-2}{3-3} = 42.$$

The tooth in the dog's dentition here wanting is *m.*3.

The following are the formulæ of the human deciduous and permanent dentitions:—

$$d.i.\frac{2-2}{2-2},\ d.c.\frac{1-1}{1-1},\ d.m.\frac{2-2}{2-2} = 20.$$

$$i.\frac{2-2}{2-2},\ c.\frac{1-1}{1-1},\ p.\frac{2-2}{2-2},\ m.\frac{3-3}{3-3} = 32.$$

The teeth of the porcine formula here wanting are, *d.i.*3, *d.m.*1, and *d.m.*2; and, in the second set, *i.*3, *p.*1, and *p.*2. Respecting the missing incisor there may be a doubt, but none as to the premolars: the teeth called *bicuspids* in anthropotomy are the homologues of *p.*3 and *p.*4 in the typical diphyodont dentition.

In Ichthyology, the characters afforded by the fin-rays, whether of texture or number, are symbolised by letters and numerals with the sign *plus*. In the Perch (*Perca fluviatilis*) e.g. they are thus noted:—

D.15, 1 + 13 : P.14 : V.1 + 5 : A. 2 + 8 : C.17

signifying that there are two dorsal fins, D, of which the first has fifteen rays, all hard or spinous, the second has one spinous *plus* thirteen that are soft: P, the pectoral fin, has fourteen rays, all soft: V, the ventral fin, has one spinous *plus* five soft rays: A, the anal fin, has two spinous *plus* eight soft rays: C, the caudal fin, has seventeen rays.

Symbolism. The name applied to the system which invested the forms of Christian architecture and ritual with a symbolical meaning. The extent to which this symbolism was carried has been a subject of much controversy. Specimens of such interpretation may be found in the writings of Hugh of St. Victor; but the system was carried out to its utmost extent in the *Rationale Divinorum Officiorum* by Durandus, bishop of Mende, in the thirteenth century. (Didron, *Iconographie Chrétienne.*)

Symmetric Functions. In Algebra, a function of two or more quantities is said to be symmetric with respect to those quantities if, independently of their particular values or any relation subsisting among them, the function is unaltered when any two of the quantities whatsoever are interchanged. Thus, the function

$$ab + cd + ce + de$$

is symmetric with respect to *c*, *d* and *e*; for it is unaltered (except in the order of the terms) when we interchange *c* and *d*, or *c* and *e*, or *d* and *e*; it is also symmetric with respect to *a* and *b*, but not with respect to *a* and *c*, or *a* and *d*, or *a* and *e*, or with respect to *b* and *c*, or *b* and *d*, or *b* and *e*. The expression

$$ab + ac + ad + ae + bc + bd + be + cd + ce + de$$

is symmetric with respect to all the letters *a*, *b*, *c*, *d* and *e*; for there is no interchange of any two letters that will alter the function. So also the expression

$$abcd + abce + abde + acde + bcde$$

is a symmetric function of the same five letters.

The sums, differences, products, quotients, powers, and roots of symmetric functions are themselves symmetric functions, provided all the functions combined by addition, subtraction, &c., contain the same indeterminate magnitudes, and in the same number. Thus, the expression

$$\frac{(ab+ac+bc)^m + \sqrt[n]{abc}}{\sqrt[p]{(abc-a-b-c)}} + \frac{abc}{\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}}$$

is a symmetric function of a, b and c, because $ab+ac+bc$, abc, $a+b+c$, and $\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}$ are severally symmetric with respect to these three letters.

It is often found convenient to represent symmetric functions by prefixing the symbol Σ to one of the terms of the symmetric function; this term is taken as a type of all the others, and the prefixed Σ denotes the sum of the terms. Thus, let there be n quantities x_1, x_2, x_3 . . . x_n, then the sum of their m^{th} powers, which is a symmetric function, viz.

$$x_1^m + x_2^m + x_3^m + \ldots + x_n^m,$$

is represented by Σx_1^m, or, more simply, by Σx^m. In like manner, the symmetric function

$$x_1^m x_2^p + x_1^m x_3 + x_2^m x_3^p + \ldots + x_{n-1}^m x_n^p,$$

formed by the permutation of the n quantities taken two at a time, and by writing the exponent m over the first quantity, and p over the second in each term, is denoted by $\Sigma x_1^m x_2^p$, being the sum of all the terms which can be formed like $x_1^m x_2^p$.

The coefficients of an equation are symmetric functions of the roots of the equation. Let x_1, x_2, x_3 . . . x_n be the roots of the equation

$$x^n + ax^{n-1} + bx^{n-2} + cx^{n-3} + \ldots = 0,$$

then

$$-a = \Sigma x_1, b = \Sigma x_1 x_2, -c = \Sigma x_1 x_2 x_3, \text{\&c.}$$

In general, any rational symmetric function of the roots may be expressed rationally in terms of the coefficients of the equation. In the *Algebra* of Meyer Hirsch are given some very useful tables of the symmetric functions up to the tenth degree of the roots of an equation of any order. By means of these tables any symmetric function of the roots, not exceeding ten dimensions, being given, its value in terms of the coefficients of the equation becomes immediately known. Prof. Cayley, in a memoir entitled 'On the Symmetric Functions of the Roots of an Equation,' published in the *Philosophical Transactions* for 1857, has recalculated and corrected Hirsch's tables, and joined to them another set, giving reciprocally the expressions of the powers and products of the coefficients in terms of the symmetric functions of the roots. In the *Cours d'Algèbre Supérieure* (1866) of J. A. Serret, the subject of symmetric functions is treated with great elegance.

Symmetrical Determinant. A determinant in which those constituents are equal which are symmetrically situated with respect to the principal diagonal. An example is presented by the important function known as the discriminant of the ternary quadric $(a, b, c, d, e, f \between x, y, z)^2$ which, expressed as a determinant, is,

$$\begin{vmatrix} a & f & e \\ f & b & d \\ e & d & c \end{vmatrix}$$

If S denote any such determinant, and $a_{i,k}$ the k^{th} constituent of its i^{th} row, then $a_{i,k} = a_{k,i}$. The determinant $S' = S^{n-1}$ of the reciprocal system is also symmetrical; and if $a'_{i,k}$ represent the element of S', which corresponds to $a_{i,k}$ in S, we have $a'_{i,k} = a'_{k,i}$ $= \frac{1}{2}\frac{dS}{da_{i,k}}$. [DETERMINANTS.]

Symmetrical Figures. In Geometry, two points are said to be symmetrical with respect to a third point, the *centre of symmetry*, when the former are equidistant from, and in the same straight line with, the latter. Two points are also said to be symmetrical with respect to a given line, *axis of symmetry*, when they are equidistant from the latter and situated on the same perpendicular to it. Lastly, two points are said to be symmetrical with respect to a given *plane of symmetry*, when they lie on the same perpendicular to this plane and are also equidistant from the latter. Similarly, two *figures* are said to be symmetrical with respect to a centre, an axis, or a plane when their points taken in pairs are so. A figure and its reflected image are symmetrical with respect to the plane of the mirror. Two figures which are symmetrical with respect to an axis can always be superposed by causing one to make half a complete rotation about that axis. When the figures are symmetrical with respect to a centre or a plane they cannot in general be superposed, though their rectilineal edges, as well as their plane and dihedral angles, are equal two and two. The volumes of two such symmetrical solids are likewise equal. Two spherical triangles whose corners are diametrically opposed to each other are symmetrical with respect to the centre of the sphere. When each is isosceles, they can be superposed, but not otherwise; nevertheless, their angles and sides are always equal, as are also their areas. Two figures which are symmetrical to the same figure, with respect to two different centres or planes of symmetry, are equal and superposable. An interesting memoir on symmetrical figures by Bravais will be found in Liouville's *Journal*, 1849. Legendre, in the sixth book of his *Eléments de Géométrie*, defines symmetrical polyhedra and examines their properties.

Symmetrical Skew Determinant. [DETERMINANTS; SKEW SYMMETRICAL DETERMINANTS.]

Symmetry (Gr. συμμετρία, *proportion*, literally *a measuring together*). In Botany, that kind of arrangement in which the number

of parts of one series corresponds with that of the other series; as, for example, when a flower with five sepals has five petals, and five or ten or fifteen stamens.

Symmetry. In the Fine Arts. [Proportion.]

Symmoria. [Trierarchia.]

Sympathetic Inks. Liquids which are colourless or so slightly coloured that characters written with them are invisible till acted upon by some reagent. The best is a dilute solution of chloride of cobalt. Markings made with it become blue when the paper on which they are written is held in front of a fire, the slightly tinted pink hydrated salt then becoming anhydrous and deeply blue.

Sympathetic Nerve. This term is applied, in Anthropotomy, to a system of nerves, which in the Vertebrate series consists of one or more ganglia, usually a series of such, arranged on each side of the bodies of the vertebræ from the occiput to the anterior caudal vertebræ. Where the ganglia are numerous, each lateral series is connected by a band of nervous fibres, and they resemble a pair of gangliated cords. They communicate with the contiguous spinal nerves, and with cranial nerves through small ganglia in different parts of the head. At the caudal end the two *sympathetic nerves* or cords unite with a single ganglion.

A *sympathetic ganglion* is a body connected with bundles of nerve-fibres, the chief proceeding to or from it in the direction of its axis, the smaller nerves diverging more or less transversely. It consists of corpuscles called *ganglion-vesicles*, and of nerve-fibres embedded in a nucleated fibrous tissue.

The nerves from the sympathetic system are principally disposed in plexuses, the chief of which, in man, are the *cardiac*, the *solar*, and the *hypogastric*; there are many minor plexuses, of which those, like the *carotid*, surrounding the arteries by the *nervi molles*, are very characteristic of the sympathetic system. The nerves from the abdominal plexuses are so distributed that the intestinal canal is under its direct influence, and indirectly to that of the myelencephalic system. Some experiments seem to show that the sympathetic nerves have more influence upon the nutritive processes than the sensory ones. The normal contraction of arteries appears to be excited by the sympathetic nerves distributed to their walls. The old name relates to a fanciful phase of physiology.

Sympathy (Gr. συμπάθεια, *fellow-feeling*). In the Fine Arts, this term signifies conformity of the parts to each other; but in Painting it is more usually applied to the effective union of colours.

Sympathy. In Moral Philosophy, the quality of being affected by feelings common to our fellow-men. In his *Theory of Moral Sentiments*, Adam Smith maintains that sympathy is the real foundation of morals. [Ethics.] For a succinct statement of this theory, see 'The Life of Adam Smith,' prefixed to M'Culloch's edition of the *Wealth of Nations*, p. iv.

Symphony (Gr. συμφωνία, from φωνή, *sound*). In Music, a composition which, from the etymology of the term, evidently implies that the voice anciently formed an essential part of its construction. In the present day, however, the term is otherwise applied, and is exclusively used for a piece in which instruments only are engaged. It is, in fact, a composition for a perfect instrumental orchestra, which until the beginning of the eighteenth century was unknown. The *concerti grossi* of Corelli were the first of the species. The idea was carried out to a greater extent in the works of Geminiani and Vivaldi; but before the time of Haydn it can scarcely be said to have assumed the form which the name now imports. There is, perhaps, no musical composition in which the power of the author is so completely developed as in a symphony. The musician in it becomes a poet, or perhaps rather a painter. Scenes and the passions are represented by a combination of musical sounds; as an illustration, we need only cite that splendid work of Beethoven known to all under the name of *Il Pastorale*. The general form of the symphony may be thus described: It opens with a short, serious, slow movement; this is followed by and forms a contrast to one of spirit and of a lively nature; then comes an andante varied, or an adagio or slow movement; a minuet with its trio follows; and the symphony usually closes with a lively rondo, or a finale of rapid motion.

Symphysis (Gr. σύμφυσις, *a growing together*). A term applied to the junction of certain bones, or to joints not admitting of motion; as the *symphysis of the pubis*.

Symphytum (Gr. σύμφυτον, *planted together with*). A genus of *Boraginaceæ*, inhabiting Europe and Central Asia, and consisting of coarse-growing perennials, with scorpioid racemes of rather large pale-yellow, purple, or blue flowers. Our native species, *S. officinale*, the Comfrey, is a well-known plant of water-courses, having much the taste and properties of borage, for which it was not unfrequently substituted in the old English cool tankard, and amongst herbalists it was highly extolled as a 'cooler of the blood.' *S. asperrimum*, a species from the Caucasus, has been much recommended as a green *soiling* plant for cattle, and is capable of producing large crops, two in the season, amounting, perhaps, to from forty to fifty tons of green food per acre. Its cultivation is easy. Divisions of its suckers may be planted in rows two feet apart, with fully a foot between each of the plants in the rows. It may be cut twice, and will yield largely, especially if some rotten dung be dug in between the rows when the plantation is dressed up for winter.

Sympiezometer (Gr. συμπιέζω, *I compress*; μέτρον, *measure*). An instrument contrived by Mr. Adie of Edinburgh for measuring the weight of the atmosphere by the compression of a column of gas. It consists of a glass tube

ABC of about 18 inches in length, bent as represented in the annexed figure, and having an enlarged portion or bulb of about 2 inches in length and half an inch in diameter at each end. The top at A is hermetically sealed, and the other extremity C can be stopped by a cork. The upper part of the tube A m is filled with some permanently elastic gas different from common air (hydrogen gas is found to answer best), and the lower m B n with a fixed oil, or with some fluid which does not act upon the gas and is not acted upon by air.

The tube being open at C, the oil is exposed to the pressure of the atmosphere, and stands at a height m, corresponding to the difference of the pressures of the atmosphere and of the column of enclosed gas. Consequently, as the atmospheric pressure becomes greater the gas will be compressed, and the column of oil will rise. The change in the bulk of the gas occasioned by a change of pressure is measured by a scale, which is formed experimentally, and of which the divisions are entirely arbitrary.

But the as bulk of the enclosed gas is altered by any change of temperature as well as of pressure, it is necessary to apply a correction on this account. For this purpose a common thermometer is attached to the instrument to indicate the temperature; and the principal or barometric scale, which measures the compression of the gas, is made to slide upon another scale so divided as to represent the change of bulk in the gas produced by a change of temperature under the same pressure, and corresponding to the graduation of the thermometer. In making an observation, the temperature is first observed by the thermometer; an index or pointer, which is fixed to the top of the sliding scale, is then set opposite to the degree of temperature on the fixed scale, and the number on the sliding scale opposite the top of the column of oil gives the pressure of the air in inches of the mercurial barometer.

The principle of the sympiezometer is the same as that of the MANOMETER, or air barometer, which was long ago proposed by Hooke.

Symplesite (Gr. συμπλησιάζω, *to draw close together*). A hydrated arseniate of protoxide of iron, which is found at Klein-Friesa in Reuss.

Symposiarch (Gr. συμποσίαρχος, from συμπόσιον, *a feast*, and ἄρχω, *I rule*). The ruler or master of a feast, selected by the consent of the party to be their president for the occasion; he was sometimes called βασιλεύς. The word rendered *governor of the feast*, in John ii. 8, is ἀρχιτρίκλινος.

Synoecia (Gr. συνοίκια, from σύν, *with*, and οἰκέω, *to dwell*). In Classical Antiquities, an Athenian festival in commemoration of the union of the little townships of Attica into one commonwealth. This consolidation of independent demi [DEMOS] into a single state was attributed to the mythical hero THESEUS.

Synaeresis (Gr. συναίρεσις, *a taking together*). Otherwise called *crasis* (Gr. κρᾶσις, *a mixture*). In Grammar, the contraction of two syllables into one by the formation of a diphthong, or by rendering one of them mute; as, Atreides for Atreïdes. [METAPLASM.]

Synagogue (Gr. συναγωγή, *a gathering*). The religious assemblies of the Jews are so called by Hellenic writers. The Jews had no synagogues, it is thought, before the Babylonish captivity. They were first formed after the return of the Jews to the Holy Land. The rule was, that a synagogue was to be erected in any place where there were ten persons of full age and free condition ready to attend the service of it. Others, however, consider the ten *batelnim*, to use the Hebrew word, to have been ten elders, or stationary men of the synagogue. (Lightfoot.) The service performed in the synagogues consisted, and still consists, of prayers, reading the Scriptures, Biblical exposition, and preaching. The prayers are contained in liturgies. The reading of the Scripture consists of three portions: the 'Shema,' certain selected passages from Deuteronomy and Numbers; the law; and the prophets. The third part of the service is mentioned in several places in the Gospel narratives and in the Acts. (Luke iv. 16, Acts xiii. 5.) The times of the synagogue service were three days a week (Monday, Thursday, and Saturday), besides the holy-days. The ministration of the synagogue was not confined to the order of priests; the elders, or *rulers of the synagogue*, were persons qualified, and duly admitted, from all tribes. (Prideaux, *Connection*, vol. i.)

Synalaepha (Gr. συναλοιφή, from ἀλείφω, *I anoint*, from the melting together of two sounds). In Classical Prosody, the usage by which, when a word ends with a vowel, and the next begins with a vowel, the final syllable of the one runs into the first of the other. This, in Latin verse, also takes place when the last letter is *m*; but the usage in this instance is called *ecthlipsis*, or elision. The synalæpha is commonly, though not with equal regularity, adopted in Italian and Spanish poetry, and is not unfrequently attempted, especially by Milton, in our own; in French it extends only to the *e* mute at the end of words.

Synaptase. *Emulsin*. A ferment existing in almonds. It has the power of breaking up amygdalin into oil of bitter almonds, formic acid, hydrocyanic acid, and sugar; and salicin into sugar and saligenin.

Synarthrosis (Gr. συνάρθρωσις, from ἄρθρον, *a joint*). The immovable connection of one bone with another.

Syncarpium (Gr. σύν, and καρπός, *fruit*). In Botany, a fruit consisting of many carpels consolidated and adhering to a central receptacle or growing point, as in *Magnolia*.

Syncarpous (Gr. σύν, and καρπός). In Botany, a term applied to the carpels of a compound pistil when they are completely

united into an undivided body; as in the Orange.

Syncategorematic (Gr. συγκατηγορηματικός, from σύν, and κατηγόρημα; a word employed together with categorematics or terms). In Logic, a word which cannot be employed by itself as a term, but must be conjoined with another or others for that purpose. Such are adverbs, prepositions, nouns in other cases beside the nominative, &c. [TERM.]

Synchondrosis (Gr. συγχόνδρωσις, from χόνδρος, *a cartilage*). The junction of one bone with another by an intervening cartilage.

Synchronism (Gr. συγχρονισμός). The tabular arrangement of history according to dates, by which contemporary persons and things in different countries are brought together. [TABULATION OF CHRONOLOGY.]

Synchronous Curve. In Mechanics, a curve which would be reached in the same time by a body or material particle falling from a given point down any one of a set of given curves belonging to the same family. Thus, if from a fixed point on an inclined plane right lines be drawn, and down the several lines particles, starting together, be conceived to fall, they will all, at any subsequent instant, be situated on the circumference of a circle which touches the *level line* at the common starting-point. This circle is the *synchronous curve* of the system of right lines. The property in virtue of which coinitial chords of a circle are described in equal times is frequently referred to as the *synchronism of the circle*.

Synclinal. [ANTICLINAL AND SYNCLINAL AXIS.]

Syncopation. In Music. [DRIVING NOTES.]

Syncope (Gr. συγκοπή, from κόπτω, *I cut*). A figure of Grammar, by which one or more letters are omitted in the middle of a word; as in the Latin *litus* for *littus*. [METAPLASM.]

SYNCOPE. In Music. [LEGATO.]

SYNCOPE. In Pathology, fainting. A disease in which the circulation and respiration temporarily cease or become extremely feeble.

Syncretism (Gr. συγκρητισμός). In Philosophy, the blending of the tenets of different schools into a system. A party among the Platonists at the revival of letters, to which belonged Ammonius, Pico della Mirandola, Bessarion, and other distinguished men, have received the name of Syncretists.

Syncretists. In Ecclesiastical History, the partisans of George Calixtus, a Lutheran divine of the sixteenth century, who endeavoured to form a comprehensive scheme which should unite the different professors of Christianity. The opinions of Calixtus raised a strong controversy in the Lutheran church. A new confession of faith was drawn up in Saxony for the purpose of excluding his partisans. His doctrines, however, did not long survive his death, although they were not without effect on the spirit of the age.

Syndactyles (Gr. σύν, and δάκτυλος, *a finger*). The name of a tribe of Perchers, including those which have the external and middle toe united as far as the second joint.

Syndesmosis (Gr. σύνδεσμος, *a ligament*). The union of one bone with another by means of ligament.

Syndic (Gr. σύνδικος, from δίκη, *justice*). A title given at different times to various municipal and other officers. The syndics of cities in Provence and Languedoc, under the old French government, were officers delegated by the municipality as agents or mandatories. Such were also the syndics of trading companies. The creditors of a bankrupt, under the law of France, appoint syndics or directors from among their number.

Synecdoche (Gr. συνεκδοχή, from σύν, *with*, ἐκ, *out*, and δέχομαι, *I receive*). In Rhetoric, a figure by which the whole is put for a part, or part for the whole. It is a species of TROPE. There are six ordinary instances of synecdoche: 1. When genus is put for species (as *being* in the sense of *man*). 2. When species is put for genus. 3. When the essential whole is put for one of its parts. 4. When the matter, or form, is put for the whole being. 5. The whole for a part. 6. The part for the whole.

Synechia (Gr. συνέχεια, *continuity*). A disease of the eye in which the iris adheres to the cornea, or to the capsule of the crystalline lens.

Synedrous (Gr. σύνεδρος, *sitting with*). In Botany, a term applied in those cases when the leaves or other parts grow on the angle of a stem.

Synergists (Gr. συνεργός, *working together*). A name given to a party in the Lutheran church in the latter end of the sixteenth century. Those who were thus called appear to have held the doctrine that the divine grace requires a correspondent action of the human will in order to become effectual; which, or something resembling it, is termed *semi-Pelagian* in early ecclesiastical history. Some sentiments expressed by Melanchthon, towards the close of his life, seem to have introduced it into that church. [PELAGIANISM.]

Syngenesious (Gr. σύν, and γένεσις, *birth*). In Botany, a term applied to flowers having the anthers united at their edges, so as to form a tube.

Syngnathians (Gr. σύν, and γνάθος, *a jaw*). The name of a family of Lophobranchiate fishes, including those in which the lengthened jaws are united by a surrounding integument, so as to form a tubular mouth: the genus *Syngnathus*, or pipe fish, is the type. *Syngnathæ* is a name given by Dr. Leach to an order of Myriapodous insects.

Syngrapha (Gr. σύγγραφος, from γράφω, *I write*). In Diplomatics, contracts signed by the creditor and debtor, and of which a duplicate original was kept by each.

Synizesis (Gr. συνίζησις). An obliteration of the pupil of the eye; a closed pupil.

SYNIZESIS. In Grammar, this term is used to denote the melting of two vowels into one.

Synneurosis (Gr. *συννεύρωσις*, from *νεῦρον*, *a nerve* or *membrane*). The union of one bone with another by means of an intervening membrane.

Synocha (Gr. *σύνοχος*, *joined together*). The old name for continued inflammatory fever. The term *synochus* was applied to continued fevers, which were in their symptoms intermediate between *synocha* and *typhus*. They were called *mixed fevers*.

Synod (Gr. *σύνοδος*, *an assembly*). In Ecclesiastical language, this term denotes the convention of the inferior clergy of a diocese by its bishop or archdeacon. [Council.]

Synod. In the Scottish Kirk, an assembly composed of two more presbyteries. It consists of every parish minister within its limits, and of the elders who have last represented the different sessions in the presbytery. There are sixteen synods in Scotland. [Presbytery.]

Synod of Dort. [Dort, Synod of.]

Synodic. In Astronomy, the synodic revolution of a planet (or the moon), with respect to the sun, is the time between two consecutive conjunctions or oppositions. The duration of this period is easily found when the difference between the mean motion of the planet and the sun in a given interval of time is known; for this difference is to 360° as the given interval to the synodic revolution. The *synodical month* is the period of the moon's synodic revolution, and is the same with *lunar month* or *lunation*. [Moon.]

Synodic Month. [Lunar Month.]

Synonyms (Gr. *συνώνυμος*, from *ὄνομα*, *a name*). Words of the same language which have a similar signification. Strictly speaking, words having exactly the same signification are not to be found in any language, unless one of them has been borrowed from another language; but in this case the shades of difference are often so slight that words may be frequently used for one another, and this interchange produces a pleasing variety in composition, necessary in poetry. The chief works on this subject are the *Onomasticon* on Greek, Dumesnil on Latin, Blair, Crabbe, and Taylor on English, Stosch and Eberhard on German, and Giraud, Beauzée, Roubaud, and Guizot on French synonyms.

The multiplication of synonyms was a main cause of the growth of myths. In the mythopœic ages there was a constant tendency to devise names denoting each of the attributes of any given object, and thus the names of prominent phenomena in the outward world would be as numerous as the aspects which from time to time they might assume. Gradually the greater portion of these names would become useless, until at last the literary dialect would choose out some one of them to denote the object to the exclusion of the rest. The more ancient languages are therefore the richest in synonyms.

These synonyms, if used constantly, 'must naturally give rise to a number of homonymes. If we call the sun by fifty names expressive of different qualities, some of these names will be applicable to other objects also, which happen to possess the same quality. These different objects would then be called by the same name—they would become homonymes.' (Max Müller, *Comparative Mythology*, 45.) [Polyonymy.]

Synopsis (Gr. *σύνοψις*, *a seeing together*). A collective view of any subject; as a synopsis of astronomy, theology, &c.

Synoptic (Gr. *συνοπτικός*, *seeing at a glance*). In Biblical criticism, this term is sometimes used to distinguish the first three Gospels, as containing generally the same succession of events, from the fourth, in which the narrative and the discourses are not the same as those given in the other Gospels.

Synovia (Gr. *σύν*, and *ὠόν*, *an egg*). The fluid which lubricates the cartilaginous surfaces of the joints: it is glairy, and resembles the white of egg.

Syntax (Gr. *σύνταξις*, from *συντάσσω*, *I arrange together*). In Grammar and Rhetoric, the disposition of the words and members of a sentence in the grammatical arrangements proper to the language. [Grammar.]

Synteleia. [Trierarchia.]

Synthesis (*σύνθεσις*, from *συντίθημι*, *I place together*). In Chemistry, those chemical operations by which compounds are obtained by the union of the separate component parts are called *synthetic*. The term is especially used as opposed to *analysis*. Thus, we demonstrate the composition of water *analytically* by resolving it into oxygen and hydrogen gases; and *synthetically*, by recombining those gases so as again to produce the water which had previously been decomposed; the terms *synthesis* and *analysis* being, in fact, synonymous with *composition* and *decomposition*.

Synthesis. In Geometry and Logic, the method of demonstration which sets out from some principle established or assumed, or from a proposition already demonstrated, and ascends through a series of propositions to that which is enunciated. Synthesis is also called the direct method or *composition*, and is the reverse of analysis or resoluion. It is the method followed in Euclid's *Elements*. For the sense in which analysis and synthesis were understood by the ancient geometricians, see Analysis.

Syphilis (perhaps coined from Gr. *σιφλός*, *crippled, defective*). The venereal disease.

Syphon. [Siphon.]

Syringa (Gr. *σῦριγξ*, *a pipe* or *tube*). A favourite genus of *Oleaceæ*, of which familiar examples occur in the various Lilacs of our gardens. The native country of some of these is not well ascertained, although the genus appears to be confined to South-eastern Europe and Central and Eastern Asia. They are deciduous shrubs with entire leaves, and terminal more or less pyramidal panicles of usually sweet-smelling flowers. The Common Lilac, *S. vulgaris*, is the largest species and also one of the most familiar and most beautiful of our spring-

flowering ornamental shrubs. The Persian Lilac, *S. persica*, is smaller, seldom growing more than six or eight feet high. There are several garden varieties of the different kinds of Lilac.

Syringe (Gr. σῦριγξ). In Hydraulics, a machine consisting of a small cylinder with an air-tight piston or sucker, which is moved up and down in it by means of a handle. The lower end of the cylinder terminates in a small tube, through which a fluid is forced into the body of the cylinder by the atmospheric pressure when the handle is drawn up, and then expelled in a small jet by pushing the handle in the opposite direction. The syringe acts on the principle of the sucking pump. The syringe is also used as a pneumatic machine for condensing or exhausting the air in a close vessel, but for this purpose it must be furnished with two valves. In the condensing syringe, the valves open downwards and close upwards; in the exhausting syringe they are closed downwards and opened upwards. [AIR GUN; AIR PUMP.]

Syringine. A crystallisable bitter principle obtained from the leaves of the lilac-tree (*Syringa vulgaris*). It has also been called *lilacine*.

Syrma (Gr. σύρμα, from σύρω, *I draw*). A long garment; so called from its train reaching the ground. It was the proper dress of actors in the classical tragedy.

Syssarcosis (Gr. συσσάρκωσις, from σάρξ, *flesh*). The junction of bones by intervening muscles.

Syssitia (Gr. συσσίτια, *common messes*). An institution of some ancient states, particularly Lacedæmon and Crete, which ordained that the male freemen should have their meals together in common messes, instead of eating with their families in private. [LIBERTY.]

System (Gr. σύστημα). In Astronomy, an hypothesis of a certain order and arrangement of the celestial bodies by which their apparent motions are explained. For an account of the systems of Ptolemy, Copernicus, and Tycho Brahe, see ASTRONOMY.

SYSTEM. In the Fine Arts, a collection of the rules and principles upon which an artist works. [DECORATION.]

SYSTEM. In Music, an interval composed, or supposed to be composed, of several lesser ones; as an octave, which is a system. [DIASTEM.]

Systemic. In Physiology, this word is applied to designate the circulation of the general system, beginning at the left ventricle and aorta, and ending at the venæ cavæ and right auricle, as contradistinguished from the circulation through the lungs, which is called *pulmonic*. They have also been termed the *greater and lesser circulations*. The parts concerned in these circulations have also received the same names: thus, the left ventricle is called the *systemic* one.

Systole (Gr. συστολή, from συστέλλω, *I contract*). In Greek and Latin prosody, a license by which a long syllable is used as short: e.g.

Matri longa decem tulĕrunt fastidia Menses.

SYSTOLE. In Medicine, the contraction of the heart.

Systyle (Gr. σύστυλος). In Architecture, the arrangement of columns in such a manner that they are two diameters apart.

Syzygetic Function (Gr. σύζυγος, *yoked together*). According to Prof. Sylvester, with whom the term originated, a syzygetic function of a set of given, rational, integral functions is the sum of the products obtained by multiplying each of the latter by another arbitrary function. The multipliers are termed the *syzygetic multipliers*, and the original functions are said to be *syzygetically related* when a syzygetic function of them can be made to vanish. (*Phil. Trans.* vol. cxliii. pt. ii. 1853.)

Syzygies (Gr. συζυγία, *conjunction*). In Astronomy, the places of the moon or planets when in conjunction or opposition with the sun.

Szajbélyite. A native hydrated borate of magnesia lately discovered by K. Peters, in limestone, at Workesthal, near Rezbanya.

Named after the royal mining officer Szajbélyi, of Rezbanya, in Hungary.

T

T. A letter belonging to the class called *mutes*. It is susceptible of numerous interchanges, both in the ancient and modern languages. (Max Müller, *Lectures on Language*, second series iii.) As an abbreviation, T. was used for Titus, Ti. for Tiberius.

T Bandage. A bandage so named from its shape; it is used to support the dressings after certain surgical operations.

Taag. The Bengal or Sunn Hemp, *Crotalaria juncea*.

Tabard. In Heraldry, a garment worn by the knights of the Tudor era. It consisted of a short frock with wide sleeves reaching to the elbows, with the arms of the wearer displayed on the back and front. It is still worn as the official dress of heralds.

Tabasheer or **Tabachir** (Pers.). A substance secreted in the joints of bamboos, in bluish-white masses with a pearly lustre, and mainly composed of silicious matter which the plant is unable to incorporate in its tissues.

It is reputed to possess tonic properties, and has peculiar optical properties, which have been investigated and described by Sir David Brewster.

Tabby (Fr. tabis, Ital. tabi). A term formerly applied to certain figured silks and other goods upon which an irregular pattern had been stamped, either by the pressure of engraved rollers, or by folding the stuffs in such a way as to produce, by the mutual pressure of their fibres, an inequality of surface which, by reflected light, gives rise to the appearance called *watering*.

Tabellions (Lat. tabellio, from tabella, dim. of tabula, from the tablets on which they wrote). In the Roman empire, officers who had charge of public documents were so called; they were also secretaries, or registrars, and in some cases judges. (Savigny, *Hist. of the Roman Law*, vol. i.) The notaries were their assistants. In France, the titles of *tabellion* and *greffier* were confounded, and Henry IV. united the functions of tabellion with those of notary; but the old title seems still to be retained (or was until the Revolution) in some few places.

Tabergite. The name given to the Pyrosclerite of Taberg, in Wormland.

Tabernacle (Lat. tabernaculum, *a tent* or *cabin*). This name is applied especially to the tabernacle which the Jews are said to have carried from station to station during their wanderings in the desert; it is described as a tent of sails and skins stretched upon a framework of wood, and divided into two compartments; the outer, named *the Holy*, being that in which incense was burnt, and the shew-bread exhibited; and the inner, or *Holy of Holies*, in which was deposited the ark of the covenant. (Exod. xxvi. xxvii.)

The Feast of Tabernacles was one of the three principal festivals among the Jews. It commenced on the 15th of the month Tisri, corresponding with September 30, and lasted seven days, during which the people dwelt in booths formed of the boughs of trees. It was instituted in commemoration of the habitation of their ancestors in similar dwellings during the forty years of their pilgrimage in the wilderness. (Lev. xxiii.)

Tabernæmontana (after J. T. Tabernæmontanus, a celebrated botanist). An extensive tropical genus of *Apocynaceæ*, the numerous species of which are either shrubs or trees, with opposite entire leaves, false stipules, and cymes of fragrant yellow or white flowers, generally in pairs at the points of the branches. Like most other dogbanes, the *Tabernæmontanas* possess a milky juice; but the milk, instead of being exceedingly acrid and drastic like that of many allied genera, is, in some species at least, perfectly bland and wholesome. This is particularly the case with the Hya-Hya or Cow-tree of British Guiana, *T. utilis*, which, when tapped, yields a copious supply of thick sweet milk, resembling that of the cow in appearance, but rather sticky from the presence of caoutchouc. The tree yields a soft white wood; and its bark is used medicinally by the Indians.

Tabes (Lat.). In Animal and Vegetable Pathology, a wasting, or disease which consists in a gradual decay of the power of growth.

Tablature (Lat. tabula, *a table*). In Music, the use of the letters of the alphabet, or any other character, for expressing the notes or sounds of a composition. It is not now a usual mode of writing. In its stricter and more original sense it is a mode of writing music for a particular instrument on parallel lines (of which each represents a string of the instrument) by means of certain letters of the alphabet. Thus, A denotes that the string is to be struck open, B that one of the fingers is to be put on the first stop, C on the second, D on the third, and so on through the octave.

Table (Lat. tabula). In Astronomy, Physics, &c. This term has two different significations. In the first place, it is used to denote merely a collection of numbers, exhibiting the measures or values of some property common to a number of different bodies in reference to some common standard. Thus we have tables of specific gravity, of refractive powers, of the expansion of substances by heat, &c. In its second signification, it denotes a series of numbers which proceed according to some given law expressed by a mathematical formula. Of this kind are the logarithmic tables; tables of the powers or roots of the different numbers; of the sines, cosines, and other angular functions; of astronomical refractions; of the equations of the planetary orbits, &c. Tables of this sort, by exhibiting at once to the eye all the different values which a given formula can have, save endless labour in calculation, and are of the utmost importance in every branch of natural philosophy. The logarithmic tables, for example, form the universal instrument of astronomical calculation; and it may be safely affirmed that without them the computations necessary for determining the places of the different bodies of the solar system, and rendering astronomy a science of practical utility, would be altogether impossible.

Table is also used in a popular sense to denote a collection of particulars brought under one view. Thus, in history, we have chronological tables; in statistics, tables of mortality at different ages, &c. The mere titles of the useful tables which have been formed in the various departments of knowledge would fill a large volume.

Table Spar. [TABULAR SPAR; WOLLASTONITE.]

Table-lands or **Plateaux.** The plains of the great continents are some of them near the level of the ocean, while others are hardly less horizontal, but are elevated to a height of several hundred or even some thousand feet. Both may be broken or even undulating, and each may be connected with mountain chains. The latter are called *table-lands* or *plateaux*.

In Europe, the Iberian peninsula is a good example of table-land. Elevated from two to

three thousand feet, and having several chains of mountains rising out of it, this table-land produces the greatest possible modification of the climate, not only of the peninsula itself, but of all adjacent countries. It includes nearly 100,000 square miles of country. There are smaller plateaux in Central France.

Great plateaux exist in the Old World in connection with the great chain of mountains crossing Asia. One of these forms the table-land of Persia. There are others farther east, some of them far more extensive. They range, at various altitudes, from 5,000 to 15,000 feet, and are crossed by the spurs of the great mountain chains of the Altai and Himalaya. The table-lands of Central Asia are much less extensive than they were supposed to be by Humboldt, but they are still little known. There is an extensive plateau in Southern India.

In Africa there is table-land in the south, but the extent is not very great. In America a considerable plateau extends from Mexico to California, and there are some small plateaux of enormous elevation amongst the Andes. The table-land of Quito occupies about 6,000 square miles at an elevation of 10,000 feet. That of Desaguardero stretches 500 miles along the top of the Andes at an average height of 13,000 feet, and a breadth varying from 30 to 60 miles.

Of table-lands some are nearly level for great distances, but others undulate, and occasionally they form the basis of lofty mountain chains. In Europe the table-land is peninsular. In Asia it chiefly extends north of the mountain chain. In Africa there are tracts of high land of the nature of plateaux ranging round the coast from Abyssinia to the Cape, and again from the Cape to near the equator. In America the chief table-lands are amongst the mountains. Australia has very little table-land.

Tableaux Vivants (Fr. *living pictures*). The name given to an amusement in which groups of persons dressed are made to represent some scene in the works of distinguished painters or authors. It is thus managed: The room in which the spectators are placed being darkened, the group assume their respective attitudes behind a frame (or some other contrivance intended to represent it) covered with gauze; and candles being so placed as to reflect light upon the group from above, the illusion is complete. These representations are not unfrequently resorted to in England; but in France and Germany they form an important feature on all festive occasions. Tableaux are often employed to represent some scene in which a riddle is concealed.

Tablets. In Roman Antiquities, pieces of ivory, metal, stone, or other substance, used in judiciary proceedings, or in the passing of laws.

Taboo. A word used by the South Sea islanders to denote something sacred, or set aside for particular uses or persons.

Tabor (Old Fr. tabour). A small drum.

Taborites or **Thaborites.** The denomination of one of the parties into which the followers of Huss, in Bohemia, separated after the death of their leader. They were so called from Tabor, a hill of Bohemia, upon which they encamped during the struggle which they maintained against the civil and ecclesiastical power. At their head stood John Ziska, who was distinguished at once for his courage and cruelty. After a long struggle, the more quietly disposed portion of the Taborites formed themselves into a religious society under the denomination of the Bohemian Brethren. They established several Christian communities, elected their own bishops, priests, and elders; drew up a rigorous plan of ecclesiastical discipline; and sent forth missionaries to various parts. Though harassed by persecutions, they continued to increase in numbers, and at the end of the fifteenth century they counted about 200 communities of adherents. At the end of this period the distinctive name and opinions of the Taborites were lost among the various assailants of the Roman church, who formed the vanguard of the Reformation in Germany. [CALIXTINES; HUSSITES.] (Milman's *Latin Christianity*, book xiii. ch. xi.)

Tabular Spar. A silicate of lime, which sometimes occurs in distinct tabular prisms, but mostly in broad prismatic or laminar masses of a white tint inclining to yellow, green, red, or brown.

It is found in Scotland in the basalt of the Castle Rock, Edinburgh, and at Glengairn, Aberdeenshire; in Ireland at Dunmore Head, county Down; at Capo di Bove, near Rome, and in blocks ejected from Vesuvius, &c. &c. [WOLLASTONITE.]

Tabulation of Chronology. The arrangement of historical or professedly historical events according to their real or supposed dates is sometimes spoken of under this name. The value of such arrangements must be tested by contemporary historical documents: if for the period in question these are defective or wanting, the value of the arrangement is either lessened or destroyed; but in no case can a tabulation be of the slightest worth so long as it rests on mere conjecture or ingenious hypothesis apart from all contemporary evidence. Nor can a starting-point be gained from some event in a genuine historical period for a series of events in narratives which are contradictory, or of which the date of composition cannot be ascertained, or which contain narratives which are manifestly mythical or fabulous. Thus, because Herodotus, who is undoubtedly an historical person, expresses his belief that Homer lived about four hundred years before his own time, we are not warranted in inferring that there ever was any one poet so called, or that that poet composed the *Iliad* and the *Odyssey*, because Herodotus was not in possession of a continuous contemporary history from the time of the supposed Homer to his own. Far less are we warranted in assigning a date to the Trojan war, and to events which in the mythical cycle long precede the rape of Helen by Paris. Thus, when

Clinton in his *Fasti Hellenici* assigns the date B.C. 1753 to Phoroneus, he is really building a house on a foundation of sand, for he can only calculate back from the date of the Trojan war, which is obtained only by another retrospective calculation from some such point as the lifetime of Herodotus, and because, thus reasoning back from a narrative which is full of manifest fable, he reaches the story of a being like Phoroneus, whom he renders credible only by stripping him of all the raiment in which mythology has enwrapped him. Our whole acquaintance with Phoroneus is derived from legends which speak of him as the father of mortal men, who, like Prometheus, imparted to them the first notion of society and even the first knowledge of fire; among his children are Apis and Niobe, whose names at once carry us into the myths of Phœbus and Heracles. In short, for us, Phoroneus, who is none other than the Vedic god of fire, Bhuranyu, is neither more nor less real than the elephant which supports the world in the Hindu mythology; and to take his name and assign to it a date imparts no knowledge whatever, while it implies the conceit of knowledge without the reality.

It may be further asserted, that, if the mere name of Phoroneus with a date fails to make us acquainted with the time in which he lived, or even to assure us of his existence, any other lists which contain mere names and dates can possess no real historical value, unless they can be checked by contemporary historical narratives. Sir G. Cornewall Lewis maintains (*Astronomy of the Ancients*) that 'there is no example of history founded on contemporary registration being reduced to mere chronology,' and denies that we learn anything more from being told that Saites, Bnon, Pachnan, Staan, Archlês, and Aphobis were the six kings of Egypt in the fifteenth century B.C. than we should learn from an authentic account of the succession of a breed of crocodiles or hippopotami in the Nile, or of a series of sacred apes in a temple for the same period.'

The case is not substantially altered when, as by recent explorers in Mesopotamia, the names of a number of Assyrian and Babylonish kings are recovered from inscribed bricks and cylinders. If it be admitted that these inscriptions have been rightly read, we are justified in believing that kings with these names lived; but until we know not merely their names, but the order in which they reigned, and have some account of their actions, we can derive very little profit from our labour, and at present the reconstructed Assyrian history is confessedly full of gaps, long intervals separating the kings of one series from those of another, and no grounds being furnished in many instances for arranging them in one order rather than in another. In such a task ingenuity or conjecture cannot be permitted; and the longest experience will not render the historian better qualified for constructing a history without the materials for his task.

It has, however, been maintained, that if a chronological scheme is found to consist of two portions, the former of which, from the inordinate duration of the reigns or for other reasons, is manifestly undeserving of credit, while the product of both corresponds with the sum of years in a cyclical era, the chronology of the later portion may be regarded as historical. This is maintained on behalf of the Assyrian chronology of Berosus by Mr. Rawlinson, in his *History of the Five Great Monarchies of the Ancient Eastern World* (i. 192). 'The later Babylonians,' it is asserted, 'clearly contrived their mythical number so that, when added to those which they viewed as historical, the sum total should be a perfect cyclical period.' To this it may be replied that the views of ancient Babylonians cannot impart an historical character to periods of which they had no written contemporary history, that we have not the slightest ground for thinking that they possessed any such documents, and, further, that the mythical character in the earlier portion of a chronological scheme furnishes no guarantee for the historical character of the later portions, while the attempt to reach historical conclusions by ingenious conjectures applied to materials which are admitted to be imperfect and unsound resembles, in the words of Sir G. C. Lewis, 'an enquiry into the internal structure of the earth, or into the question whether the stars are inhabited,' and is an effort 'to solve a problem for the solution of which no sufficient data exist.' It may further be asserted that in a scheme parts of which are confessedly artificial we have no right to set aside all the factors in the sum except the last, and then to say that this last must represent an historical period. It was remarked by Niebuhr, in his *History of Rome*, that, 'according to the chronology of Fabius, the history from the founding to the taking of the city divides itself into two portions, 240 years under the kings, and 120 after them, or, to express it differently, into three periods, each containing ten times twelve years, twelve being the number of the birds in the augury of Romulus. This scheme was the bed of Procrustes, to which whatever was known or believed about the early time was fitted.' The first part of the task was to tabulate the kings; and as these were seven in number, this was done by making the middle of the reign of the fourth king coincide with the middle of the whole period of twenty-four years assigned to all seven. To this king a reign of twenty-three years was given, because twenty-three, together with seventy-seven assigned (as being what was called the *heroic secle*) to Romulus and Numa, makes exactly 100, and because 132, the year in which his reign was thus made to close, was the number of the astronomical years in a secle. This chronology Niebuhr pronounces to be throughout 'a forgery and a fiction.' A fabrication of a similar kind, though far less complicated and ingenious, is found in the chronology of the Æscings, or founders of the kingdom of Kent, in which the events take

place in an eight times repeated cycle of eight years, the ὀκταετηρίς of the Greeks. (Lappenberg, *History of England under the Anglo-Saxon Kings.*) Thus, twice eight years after his arrival Cerdic gains possession of the Isle of Wight; having spent thrice eight years in Britain, he takes the title of king; having reigned twice eight years, he dies, five times eight years having passed since his landing in this country.

The conclusion seems to be, that, 'if it is impossible to write history without names, it is equally impossible to reduce history to mere names,' and that from known historical events belonging to a period for which we have the acknowledged testimony of contemporary witnesses we cannot argue back to a period for which such testimony is either wanting or has been lost. It is no part of the historian's office to point out precisely where the true statements end and the false statements begin. The historian Hecatæus was as real a person as William the Conqueror; but he maintained that his sixteenth ancestor was a god. In his genealogical list therefore some names were as certainly false as others were true; but while it is impossible to draw a line of demarcation at any precise point, we know that the first link in the chain is a fiction. The history of the Peloponnesian war is true because Thucydides wrote it from his personal knowledge and after a diligent examination of those who took part in the struggle; his history of the Trojan war is a narrative of events every one of which may have taken place, but for the occurrence of which we have not the slightest evidence; but the account of this struggle, as given in the *Iliad*, we know to be unhistorical, because it abounds with impossibilities from beginning to end. Hence the persons who are said to have lived before the Trojan war become, if possible, even less historical than Agamemnon, or Phœnix, or Sarpedon; and a tabulation of the chronology of these mythical ages, or of any period for which we have not direct contemporary evidence, becomes a mere waste of labour, from which it is useless to expect any results beyond the multiplication of fallacies and fictions.

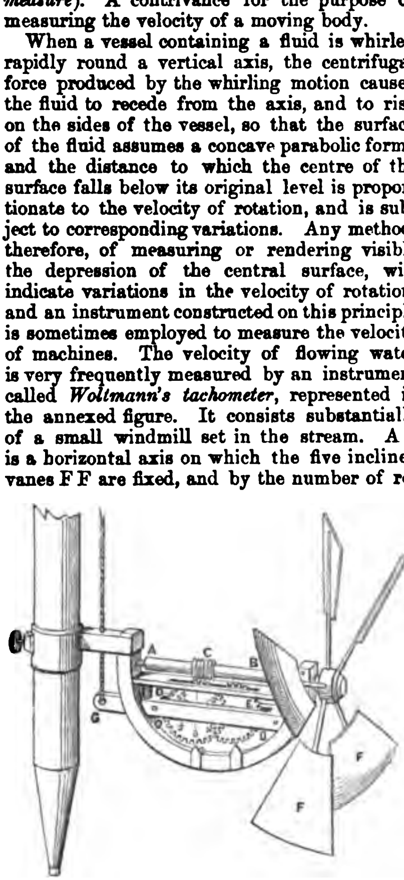
Tacamahac (an Indian word). A balsamic bitter resin, different varieties of which are attributed to *Icica Tacamahaca*, to *Elaphrium tomentosum*, and to *Calophyllum Inophyllum*. East Indian Tacamahac is the resin of *Calophyllum Calaba*. The name Tacamahac is also given in America to the resin obtained from the buds of the Tacamahac Poplar, *Populus balsamifera*.

Tacca (its Malay name). The tropical genus *Tacca*, belonging to the group of regular-flowered monocotyledons with an inferior ovary, has been considered sufficiently distinct in organisation to form the order *Taccaceæ*, though some botanists would include it in *Burmanniaceæ*. It consists of perennial herbs, with a tuberous root, radical, entire or divided leaves, and greenish or brown flowers in an umbel on the top of a simple leafless scape, surrounded by an involucre of simple bracts. The leaf-stalks of *T. pinnatifida* are plaited into bonnets by the Society Islanders, but the principal use of all the species is that of their tubers, which resemble new potatoes, and contain a great deal of starch known as South-sea Arrowroot, which is said to be far preferable to any other arrowroot in cases of dysentery. The tubers are dug up after the leaves have died away, and are rasped and macerated four or five days in water, when the fecula separates after the manner of sago. It is largely employed as an article of diet throughout the tropics.

Tacet (Lat. *it is silent*). In Music, a term denoting that through the movement to which it is affixed in any part, that part is to lie still or be silent during its performance.

Tachometer (Gr. τάχος, *speed*, and μέτρον, *measure*). A contrivance for the purpose of measuring the velocity of a moving body.

When a vessel containing a fluid is whirled rapidly round a vertical axis, the centrifugal force produced by the whirling motion causes the fluid to recede from the axis, and to rise on the sides of the vessel, so that the surface of the fluid assumes a concave parabolic form; and the distance to which the centre of the surface falls below its original level is proportionate to the velocity of rotation, and is subject to corresponding variations. Any method, therefore, of measuring or rendering visible the depression of the central surface, will indicate variations in the velocity of rotation, and an instrument constructed on this principle is sometimes employed to measure the velocity of machines. The velocity of flowing water is very frequently measured by an instrument called *Woltmann's tachometer*, represented in the annexed figure. It consists substantially of a small windmill set in the stream. A B is a horizontal axis on which the five inclined vanes F F are fixed, and by the number of re-



volutions made by the axis in a given time the velocity of the stream is determined. The axis has a few turns of a screw C formed on it, which work into the wheel D, which in its turn works the wheel E or any other train of wheel-work, and by this wheel-work the number of

revolutions is recorded, and is read off by the aid of suitable figures on the sides of the wheels. The entire instrument is screwed to a staff having a tin vane attached to it to enable it to be kept opposed to the current, and in order that the wheel-work may revolve only during the time of observation the wheels are carried in a hinged frame G O, by tightening a cord at the end of which the wheel D is brought into gear with the screw C on the axis, whereas by relaxing the cord the axis runs loose without acting on the wheels. The principle of this machine is similar to that of the patent log by which the speed of vessels is measured.

Tachyaphaltite (Gr. ταχύς, *quick*, and ἅφαλτος, *springing off*). A mineral of a dark reddish brown colour which is found in short thick prisms in the granite veins of Krageroe, in Norway. It is probably an altered Zircon.

The name has reference to the tendency of the mineral to fly off from the gangue when struck.

Tachydrite (Gr. ταχύς, and ὕδωρ, *water*). A very deliquescent salt, resembling Carnallite, which occurs in roundish masses of a yellow colour in the compact Anhydrite of Stassfurt. It is a hydrated chloride of calcium and magnesium.

Tachydromians (Gr. ταχυδρόμος, *fast running*). The name of a family of wading birds, of which the genus *Tachydromus* is the type. The term is also applied to a family of Saurian reptiles by Fitzinger, and to a family of Dipterous insects by Mirgen.

Tachydromus (Gr. ταχυδρόμος). A subgenus of *Lacertidæ*, differing from the true lizards in having a very long body and tail, with their fore legs very distant from the hind legs, and the back covered with scales similar to those on the belly. They are found in the Indian islands and China, and run with great velocity; whence their name of *swift lizards*.

Tachygraphy (Gr. ταχύς, and γράφω, *I write*). One of the many names of Greek derivation which have been given to the art of short-hand writing. [STENOGRAPHY.]

Tachylite (Gr. ταχύς, and λίθος, *stone*). A kind of Isopyre of a velvet-brown or black colour, found on the Säsebühl, near Dransfeld, and at Höllengrund, near Münden, forming small masses in Basalt and Wacke. It is a silicate of alumina and protoxide of iron. The name has reference to its rapid fusibility.

Tack (Gr. τάσσω, Ital. attaccare, Fr. attacher, *to arrange* or *fasten*). In Naval language, the weather clue or corner of a course, as also of any sail set with a boom or gaff, and of a flag. Also, the rope by which such clue is extended: thus, the *main tack* is the rope by which the tack or weather clue of the mainsail is drawn down to the ship's side.

A ship is said to be on the *starboard tack* when she is close-hauled, having the wind on the starboard side; and on the *port tack* when the wind is on the port side. *To tack* is to change from one tack to the other by bringing the vessel's head to the wind, and shifting the tacks of the sails from the one side to the other.

Tacking. In Law, a right which mortgagees possess in some cases of consolidating their securities. Thus, if there be three successive mortgages on the same estate, and the third mortgagee advanced his money without notice of the existence of the second mortgage, he may take a transfer of the first mortgage, and hold the legal estate which he thereby acquires until both his charges are paid off, thus *squeezing out* the second mortgagee. This doctrine prevents any charge on land except legal first mortgage being a really satisfactory security.

Tackle (Dutch takel). A simple tackle consists of one or more pulleys rove with a single rope. The rope is termed a *fall*. The pulleys are called *blocks*; the shell, or frame, contains the *sheaves* of the pulley which turn on a pin. When a tackle is in use, one end of the fall is made fast, and called the *standing end*; the other is hauled upon, and called the *running end*. *Overhauling* a tackle is separating the blocks; *fleeting* blocks is bringing them close together by hauling on the fall. Wooden blocks are generally bound on the outside, in the direction of their length, with a grummet, which is called the *strap* of the block. If this strap be continued so as to form a tail, the block is called a *tail* or *jigger block*, and a tackle with its movable block so furnished is called a *jigger tackle*. Bothway's patent blocks are now much used; they are iron strapped, the pin is better supported, and of smaller diameter; they have iron swivel-hooks.

The following are the principal points to be attended to in the use of tackles: 1. The condition and strength of the straps, hooks, and cordage. 2. That the fall is free from kinks and turns, and enters freely into the grooves of the sheaves. 3. The nature of the fastenings of every kind, which must be such as to insure security. 4. The proper stoppering the fall when necessary. [STOPPERING A FALL.] 5. The prevention of accidents by men treading on or striking the fall when taut. 6. The position of the men, which should be such as to insure their safety in case of accident to the tackle.

The chief simple tackles used are a whip; whip upon whip; gun tackle; luff tackle; gun tackle; but many other combinations of pulleys are used. The increase of effect produced by any simple tackle is represented by the sum of the returns of the fall, which act immediately upon every movable block in it.

In a combination of tackles, where one acts on the running end of another, the result of their combined actions is found by multiplying together the values of the several simple tackles. It must be borne in mind, that the use of tackles affords an increase of power only at the expense of time.

Tacsonia (Tacso, its Peruvian name). A genus of ornamental shrubby climbing *Passifloraceæ*, having the general appearance of

Passiflora, and the same structure of stamens, pistil and fruit, but differing in the great length of the cylindrical tube of the calyx, which is furnished with two crowns, one at the throat and the other near its base. In *T. manicata*, a very handsome species, the tube scarcely exceeds in length that of a passion-flower. The species are natives of Central America and the West Indies. The fruit of several of them, as of other *Passifloraceæ*, viz. *T. mollissima*, *tripartita*, and *speciosa*, are eaten.

Tactical Point. In War, any point on a field of battle which may impede the advance of an enemy to your attack, or may facilitate the advance of your army to attack the enemy. *Tactical decisive points for offence* are all those which, when occupied by your army, will enable it to make an attack on the enemy the success of which would be decisive on the issue of the engagement; or those in possession of an enemy which will enable him to frustrate your attack on any other point of his position, or to intercept your line of retreat if repulsed. Reversing these conditions, we have *tactical decisive points for defence*. The flanks and most advanced salients of the position are in general the most decisive points.

Tactics (Gr. τακτικός, from τάσσω, *to arrange*). The science of moving troops in the actual presence of and contact with an enemy. The chief object is to place in action at the most important points of attack a force stronger, either numerically or by advantage of position, than that of the enemy. [Battle; Strategy; War.]

Tactics, Naval. The expression *naval tactics* is commonly understood to relate to the attack or defence of fleets or single ships; but as tactical manœuvres are necessarily practised also in keeping any number of ships together, whether for hostile or other purposes, the subject, in fact, includes all considerations relative to the closing or separating of vessels at sea. In the days of sailing fleets, very elaborate rules were laid down for the management of ships, so that each should avail itself of the wind, without taking it from a neighbour, and so on. The introduction of steam has now made ships in great measure independent of the wind. Prescribed tactics would therefore be an anachronism, and the motions of each fleet in action must be regulated by the plan of the commander-in-chief based upon the actual circumstances of the time. [Ram.]

In action, it appears to have been the custom to endeavour to engage the enemy's whole fleet, ship to ship. This, however, was, in most cases, easily avoided, and actions were consequently often indecisive. The circumstance of Lord Rodney's passing through the French fleet on the 12th of April, 1782, seems to have drawn attention to the principle of separating the enemy's fleet into portions which might be attacked in detail. The merit of suggesting the breaking of the enemy's line on this occasion has been attributed to Mr. Clerk of Eldin, author of a work on Tactics which appeared at the time, but the manœuvre had been already treated in French and Spanish works on Tactics. One of the most striking applications of the principle was exhibited in Lord Nelson's attack at the battle of the Nile.

At the present day, when fleets consist of ironclads and rams, all armed with monster artillery, the prevailing tactic is naturally to try to keep out of the way of being hit or run down, a proper precaution, since to be run down by a ram is to be almost certainly sunk. Hence, fleets in action require far more space than formerly.

Among the works on Tactics may be noticed, *Tactique Navale*, by the Count Morogues, which was considered an improvement on Le Père Hoste's work; *Tactica Naval*, by Salazar; and Mr. Clerk of Eldin's *Naval Tactics*, above quoted. Much information is contained in Admiral Ekin's *Naval Battles*; and remarks on the tactics of single actions are found in Sir Howard Douglas's *Naval Gunnery*. Some other works on the subject will be found in any good catalogue of naval books.

Tactinvariant. The invariant which, equated to zero, expresses the condition that two quantic curves or surfaces touch each other. A purely algebraical definition extending to quantics in general could easily be given. The *reciprocant* of any quantic, i.e. the function which, equated to zero, expresses the condition that the line $x\xi + y\eta + z\zeta$ touches any curve, is a tactinvariant, as well as a Contravariant.

Taction (Lat. tactio, *a touching*). In Geometry, the same as *tangency* or *touching*. [Tangent.]

Tacuari. The South American name of certain species of the Euphorbiaceous genus *Mabea*, whose hollow shoots are used as tobacco-pipes.

Tænia (Lat.; Gr. ταινία, *a fillet*). A genus of intestinal worms, commonly called the *tape-worm*. The principal tape-worms infesting the human body are: the *Tænia lata*, Linn., now the type of the genus *Bothriocephalus*—this rarely occurs in Great Britain; the *Tænia saginata* or *mediocanellata*, endemic in Abyssinia and Caffraria, occasionally occurring in England; the *Tænia solium*. When this worm infests the bowels, it often produces a variety of anomalous symptoms, and is very difficult to get rid of. A great number of specifics have been recommended for the cure of tape-worm, some of which seem to possess the power of destroying the creature, such as oil of male fern, Kousso (*Brayera anthelmintica*), &c. The embryo of *Tænia* is excluded from the egg as a bladder-worm or hydatid, and is usually introduced, as such, with the meat of the animal so infested, into the human bowels. Thorough cooking of meat is the proper preventive. [Entozoa.]

Tænia. In Architecture, the lintel above the architrave which separates it from the frieze, in the Doric order.

Tænioids (Gr. ταινιοειδής, *like a riband*). The name given by Cuvier to a family of

Acanthopterygious fishes, comprehending those which have a flattened ribbon-shaped body; also the name of a family of Sterelminthoid intestinal worms, of which the tape-worm (*Tænia*) is the type.

Tafelspath. [TABULAR SPAR; WOLLASTONITE.]

Taffety. A thin glossy silken fabric, formerly much used in England. It is extensively used on the Continent for window curtains.

Taffia. [TAFIA.]

Taffo. A manure made in China, composed of night soil mixed up with clay and formed into cakes which are dried in the sun.

Taffrail (Dutch taffereel). The uppermost rail of a ship's stern.

Tafga. The fragrant North African *Rhaponticum acaule*, which has the violet-like odour of *Acacia Farnesiana*, the Cassie flowers of the perfumers.

Tafia or **Taffia** (Fr.). A variety of rum prepared in the West Indies by the fermentation of the molasses of cane sugar.

Tages. An old Etruscan divinity, who is represented to have sprung as a beautiful boy from the earth which a ploughman had furrowed too deep. Tages at once taught the Etruscans to foretell from the flight of birds what was to happen, and immediately afterwards he died. Hence he was worshipped as the inventor of augury. [AUGURS.] A collection of his prophecies was preserved in the books of Tages.

Tagetes. The showy annuals cultivated under the names of African and French Marigolds are the most familiar representatives of this genus of *Compositæ*, the species of which are natives of Mexico, Peru, and Chili, but are also grown in China and India, and in some parts of the latter country are considered sacred flowers. The scent of the common species is strong and offensive, but the continuous flowering *T. tenuifolia*, with very finely cut leaves, has a more agreeable balsamic smell.

Tagilite. A hydrous phosphate of copper of an emerald-green colour, found in fungoid or botryoidal masses, at Nijni-Taguilsk, in the Ural, on Brown Iron-Ore.

Taglia (Ital.). In Mechanics, the name given to a particular combination of pulleys. 'The taglia consists of a system of fixed pulleys collected in one common block, and also of a system of movable pulleys in a separate block, to which the weight is attached, with one string going round all the pulleys, and having one of its ends fixed to a point in the system, and the other end going from one of the fixed pulleys drawn by the power.' (Venturoli's *Mechanics*, by Cresswell.) Sometimes several taglias are combined, so that one acts upon the other; the system is then a *compound taglia*. [PULLEY.]

Tagliacotian Operation. The operation for the restoration of the nose, the *Rhinoplastie* of the French. The merit of inventing this operation is usually given to Tagliacotius, a Venetian surgeon, who wrote upon the subject in 1598, and proposed the replacement of the deficient organ by an artificial nose cut out of the skin of the shoulder or arm. A supposed modern improvement consists in having recourse for the new materials to the skin of the forehead, out of which a triangular piece is so cut that it may retain connection at its apex, which is downwards, and so admit of being twisted or turned down to form the artificial nose by adhesion to the recently cut surfaces of the truncated organ. It appears that this operation was practised in India from time immemorial, and that it was also not uncommonly resorted to by the Italians, and especially the Romans, among whom the loss of the nose was a punishment of not unfrequent infliction. (*An Account of Two Successful Operations for restoring a lost Nose*, by J. C. Carpue, London 1816; Liston's *Practical Surgery*, London 1837; and Cooper's *Surgical Dictionary*.)

Tagus (Gr. ταγός). In Ancient Greek History, the title of the president of the Thessalian confederacy.

Tail (A.-Sax. tægl). In Architecture, the bottom of any member, or of a slab, or tile. A *tail trimmer* is the trimmer next the wall, into which the ends of joists are inserted in order to avoid the flues. To *tail in* anything is to fix one end in the wall, so that the leverage exercised by the projecting part should be counteracted by the weight above it.

Tail. [FEE TAIL.]

Tail Estate. In Law. [FEE TAIL.]

Tail, Reproduction of. When the tail of lizards, newts, and salamanders is severed, a new tail is commonly developed; but instead of its being segmented into a series of vertebræ, the notochord merely developes an undivided and styliform osseous covering.

Tail-pieces. In Printing, ornaments, in wood or metal, placed in short pages, partly to fill up the vacancy. [FAC; HEAD-PIECES.]

Taille (Fr. tailler, *to cut* or *slice*; a portion taken out of an estate, as in English an estate tail: the modern Latin form is tallia or tallagium). In Ancient French Jurisprudence, any imposition levied by the king or any other lord on his subjects. The *royal taille*, in old France, which was the impost commonly understood under the general name, was a personal or rather mixed contribution, from persons not noble or ecclesiastical, or enjoying certain other exemptions, imposed according to their supposed ability, and measured by their goods. As falling on the agricultural class, it is described by Adam Smith as 'a tax on the supposed profits of the farmer, which they estimate by the stock which he has upon the farm.' (Book iii. ch. ii.) In Languedoc, and one or two other districts, the taille was real, i.e. imposed on land and goods. This tax was rendered annual and permanent in 1445. The exceedingly unfair and oppressive nature of the taille was one of the causes which led to the French revolution. [ROTURIER.] The *real* taille is now replaced by the *contribution foncière*, and the personal by the *contribution personnelle et mobiliaire*.

Tailloir (Fr.). In Architecture. [ABACUS.]

Tailzie or **Entail.** In Scottish Law, this term signifies, in general, any deed whereby the legal course of succession is cut off and an arbitrary one substituted. But, more strictly, a deed of tailzie is one framed in terms of the statute 1685, c. 22, and designed to secure the descent of an heritable estate to the series of heirs and substitutes called to the succession by the maker of the tailzie. The principal difference between Scottish and English entails lies in the absence of any provision, in the law of the former country, similar to the fictions of fines or recoveries in the latter, whereby parties in possession were enabled to cut off the entail. Several statutes have been passed since that of 1685 to give heirs of entail in possession certain liberties which they could not otherwise possess; of which the 'Rutherford Act' (1848), 11 & 12 Vict. c. 36 (amended by 16 & 17 Vict. c. 14), is now the ruling statute, giving power to heirs born since its date to disentail on majority, and otherwise relaxing the law as to those already born.

Tal or **Tala.** An Indian name for the Palmyra Palm, *Borassus flabelliformis*.

Talapoins. The title, in Siam, of the priests of Fo, who are called in China, Seng; in Tartary, Lamas; and by Europeans, Bonzes.

Talbot. A hunting dog, between the hound and beagle. The term is now almost obsolete.

Talbotype. A photographic process so called in honour of its inventor, Mr. W. A. Fox Talbot. [PHOTOGRAPHY.]

Talc (Ger. talk, probably akin to talg, *tallow*). A very widely diffused mineral which enters into the composition of many crystalline rocks, in which it also sometimes forms extensive beds. It is a hydrated silicate of magnesia, rarely met with crystallised, but generally in granular, or foliated, masses of various colours, frequently apple-green or silver-white.

It is met with at Greiner, in the Tyrol; Sahla, Fahlun, and other places in Sweden; the Pyrenees, &c.

Talc forms the basis of the *rouge* used by ladies; it is also employed by tailors for marking lines on cloth, and in a powdered state for making gloves and boots slip on easily, and to diminish the friction of machinery.

Talc Apatite. A variety of Apatite containing magnesia, found in the chlorite-slate of the Schischimskian Mountains, in the Ural.

Talc Spar. [MAGNESITE.]

Talcite. [NACRITE.]

Talent (Gr. τάλαντον). A Grecian weight, which was much used in the computation of money. It contained sixty minæ; but its value varied in different states. The Attic talent was equivalent to about 198*l*. of English money; the Æginetan to 331*l*.

Tales (Lat.). In Law. If by reason of challenges or other causes a sufficient number of jurors do not appear at a trial, either party may pray a tales; i.e. may pray the judge at the trial to allow a sufficient number of qualified men who happen to be present (tales circumstantibus) to be joined with the other jurors to make up the twelve. In practice this seldom arises, except in the case of special jury trials, when the talesmen are taken from the common jury panel in the same court. [JURY.]

Talesfur. An Indian name for the highly fragrant leaves of *Rhododendron Anthopogon*, used as a medicinal snuff in India.

Talionis Lex (Lat.). A punishment in which a person convicted of a crime suffered exactly in the same manner as he had offended: thus an eye was required for an eye, and a tooth for a tooth. This mode of punishment was recognised by the Mosaic law, and was in some cases imitated by the Romans. If, from a more advanced point of view, it appear barbarous, we should not forget that the idea of retaliation is a restriction on the license of unlimited vengeance. The fallacy of the theory is exposed in an apophthegm attributed to Lord Bacon, which states that in Flanders a Flemish tiler fell accidentally on a Spaniard, whom he killed without being hurt himself, and when the next of blood insisted on the lex talionis, the judge remarked that, if he urged that sentence, he should go to the top of the house and then fall down upon the tiler.

Talipat or **Talipot.** The Indian names of certain kinds of Palms, called by botanists *Corypha umbraculifera* and *C. Taliera*.

Talisman (from the Arabic, dual of the noun telesm). Among the Eastern nations, a figure cut in metal, stone, &c., supposed to have been made with particular ceremonies, and under particular astrological circumstances, and to possess various virtues, but chiefly that of averting disease or violent death from the wearer. In a more general sense, any portable object endowed with imaginary influence in controlling evil spirits, &c., has been so designated. The term is frequently used as synonymous with AMULET; but the latter is not believed to possess such extensive powers as the talisman. (See a curious article in the *Encyclopædia Metropolitana*.)

Talkoid. Sparry crystalline Talc from Presnitz.

Tallage (from Fr. taille). In the language of the old English Law, this word is said by Sir E. Coke to be a general name for all taxes. According to the practice of early feudal history in England, the tallage or toll levied by the lord on his dependants, and derivable from the produce of the lands which they held of him, was arbitrary and discretionary in the case of villeins, paid as a rent in that of socagers, and in compensation for military duties in that of tenants by knight service. The power, however, of levying discretionary tallage was checked by the Great Charter; and it appears to have been early held, that the mesne lord could not claim a tallage from his tenants except with the king's consent. By the latter end of the thirteenth century, it is clear that even villeins were exempt from arbitrary tallages. Hence the right of levying a tallage was never so

oppressive as the taille in France. [TAILLE; TOLL.]

Talleh. An Arabic name for the Abyssinian Myrrh, produced by *Acacia Sassa* and *A. gummifera*.

Tallicoonah. A medicinal oil, called also *Kundah oil*, made in Sierra Leone from the seeds of *Carapa guineensis*, sometimes called *C. Touloucouna*.

Tallow (Ger. talg). Animal fat separated from membranous matters by fusion. It consists chiefly of stearin with a small quantity of olein.

Tallow is an article of great importance. It is manufactured into candles and soap, and is extensively used in the dressing of leather, and in various processes of the arts. Besides our extensive supplies of native tallow, we annually import a very large quantity, principally from Russia, whence more than half our imports reach us; the imports of tallow from that country exceeding 30,000 tons a year, while those from Australia and South America may be stated as averaging 4,000 and 2,000 tons respectively: the whole imports into this country from all quarters having been 1,160,219, 1,014,566, and 1,361,248 cwts. in 1863, 1864, and 1865 respectively.

Tallow-tree. *Stillingia sebifera*, the seeds of which are covered with a waxy substance, used in China for making candles.

Tally (Fr. tailler, *to cut*). The practice of keeping a pledge, conveying orders, or guaranteeing accounts by laying two sticks of the same size together, and making similar notches in each, is exceedingly ancient. It was the *symbolum* of the Athenians, probably the SCYTALE of the Spartans, and it was the *tally* of this country; a mode of reckoning only lately antiquated, if indeed it be quite extinct. The same convenience is the basis of the legal *indenture*.

Up to within the last forty years, the public income was checked by tallies made of hazel or ash rods, *indented* and *split into two parts*, one part being retained by the payer, the other by the teller of the exchequer. Daily sales of milk to private families were registered in the same way, as were also the scores kept by brewers against publicans. It is said that the more modern system of account-books is not found to be possessed of checks equal in point of safety to these ancient modes of reckoning.

Talmud. The traditionary or unwritten laws of the Jews. It is called *unwritten*, to distinguish it from the textual or written law; and is, in fact, the interpretation which the rabbins affix to the law of Moses. This interpretation embodies their doctrine, polity, and ceremonies, and to it many of them adhere more than to the law itself. [RABBINISM.]

The word is derived from Heb. lamad, *he taught*. The Talmud, therefore, is a book, or volume, which contains such doctrines and duties as are *taught* to the Jews by their own authorised *teachers*, the ancient rabbins.

There are two Talmuds, that of Jerusalem and that of Babylon: not to mention those of Onkelos and Jonathan, which are rather paraphrases than volumes of traditionary doctrines.

The Talmud of Jerusalem consists of two parts—the *Gemara* and the *Mischna*. The *Mischna* signifies a doubling or reiteration; the *Gemara*, a work brought to perfection or completed—from the Chaldee *gamar*, to finish or complete. The Gemara and the Mischna together, strictly speaking, form the Talmud; but the rabbins sometimes designate the Pentateuch of Moses the *first* part of the Talmud.

The Mischna is the work of Rabbi Judah Hakkadosh, 120 years after the destruction of the temple of Jerusalem. It is written in a tolerably pure style, and its reasonings are much more solid than those of the Gemara, which was written about 100 years afterwards by Rabbi Jochanan, the rector of the school at Tiberias. These two works form the Jerusalem Talmud.

But the Talmud of Jerusalem is less esteemed than the Talmud of Babylon formed by Rabbi Asa or Aser, who had an academy for forty years at a place called Sara, near Babylon, whence it was denominated the Babylonish Talmud. It is this Talmud which the Jews more frequently consult; and it is especially esteemed by those Jews who live beyond the Euphrates from the circumstance that it was compiled at Babylon. Rabbi Asa died before this celebrated commentary on the Mischna was completed; but it was finished by his disciples (some say his children) about 500 years after Christ. With the exception of the sacred authors, these Talmuds, after the Chaldee paraphrases, are the most ancient books of doctrine possessed by the Jews.

A converted Jew in the year 1238 detected several errors in the Talmud, which he laid before Pope Gregory IX., who required the archbishop of France and the kings of Spain and Portugal to seize and burn all such books of the Jews, and twenty cartloads of Hebrew books were accordingly burnt in France alone. Pope Paul IV. and Clement VIII. also signalised themselves in destroying all the Talmudic books that could be found, and many thousand volumes of the Talmud were by their orders juridically condemned to the flames.

The Talmud of Jerusalem was printed in one vol. folio, and that of Babylon in twelve and fourteen vols. folio, which we find in a bookseller's catalogue thus described: 'Talmud Babylonicum Hebraicum integrum ex Sapientum Scriptis et Responsis compositum a Rab. Aser, additis Comment. Rab. Sal. Iarchi et Rab. Mosis Maimonidis, Hebraice, 14 tom. folio, Amstelodami 1644.'

Two curious works on the traditions and doctrines of the Jews, and selections from the Talmud, were written by Peter Stehelin and W. Wotton; the former entitled *Traditions of the Jews with the Expositions and Doctrines of the Rabbins contained in the Talmud and other Rabbinical Writings*, 2 vols. 8vo. 1742; the latter, *Miscellaneous Discourses relating to the Traditions and Usages of the Scribes and Pharisees*

in our Saviour's Time, 2 vols. 8vo. 1718. (*Encyclopædia Metropolitana*; Wolff, *Bibl.* ii. 658; Eisenmenger, *Das entdeckte Judenthum*; Milman's *History of Christianity*; Renan, *Les Apôtres*, Introduction; Remarks on the Study of it in *Quart. Rev.* vol. xliii.) [CABALA.]

Talon (Fr.). In Architecture, the same as OGEE.

Talookdar (Hin.). In India, the holder of a talook, or district, generally smaller than that held by a zemindar, with proprietary rights, concerning the validity and extent of which, in some portions of the old Mogul empire, there has been much dispute: some regarding them as originally mere collectors of revenue, others as possessed of a property in the soil, to whom the actual cultivators are mere subordinate holders. In Oude, in particular, the case of the talookdars, a wealthy and numerous body, has afforded of late much subject of discussion.

Talpa. A genus of burrowing insectivorous mammals called *moles*; of which some species (*T. cæca*, Savi) appear to be blind; others, as our indigenous *Talpa europæa*, have minute eyes and a limited range of vision. The mole is remarkable for the complicated regularity of its subterraneous dwelling and galleries.

TALPA. In Surgery, a tumour under the skin or cuticle, commonly called a *mole*.

Taltalite. A mineral found in large quantities near Taltal, in the desert of Atacama, in Peru, where it forms the bulk of the copper ore derived from the mines. It occurs in masses consisting of an agglomeration of long crystalline fibres of a black or brownish-black colour, and consists chiefly of silicate of copper, together with the silicate of alumina and peroxide of iron.

Talus (Lat. *the ankle*). The sloping heap of fragments accumulated at the foot of a steep rock.

The term *talus* has also been applied to the *astragalus*, one of the bones of the ankle.

Tamanu. A green heavy resin from the Society Islands, obtained from *Calophyllum inophyllum*.

Tamarac. A North American name for the Hackmatack, or American Larch, *Larix americana*.

Tamaricaceæ (Tamarix, one of the genera). An order of hypogynous Exogens, consisting chiefly of shrubs or undershrubs, found growing in maritime sands, or in sandy or gravelly places along torrents in mountain districts. Allied in many respects to *Portulacaceæ*, *Elatinaceæ*, and *Hypericaceæ*, they are at once known by the structure of the ovary, which is not completely divided into cells, but contains three placentas erect from the base of the cavity, these being either quite free, or cohering variously with each other or with the walls of the cavity, so as to form three imperfect cells; and by the erect seeds bearing long hairs.

Tamarindus. This name is supposed to be derived from the Arabic *Tamar*, signifying *dates*, and *Indus*, in allusion to the country whence the tree was originally derived. The Tamarind-tree, *T. indica*, is the only species of the genus, but the East Indian variety has long pods, with six to twelve seeds, whereas the variety cultivated in the West Indies has much shorter pods containing one to four seeds. The

Tamarindus indica (fruit).

tree has an elegant appearance, from its graceful pinnated foliage and its racemes of sweet-smelling flowers. Tamarind-pods, as imported from the East Indies, vary in length from three to six inches, and are slightly curved. They consist of a brittle brown shell, within which is a soft acid brown pulp, traversed by strong woody fibres; the seeds are again immediately invested by a thin membranous covering. West Indian tamarinds are usually imported preserved in syrup, the outer shell having been removed. Tamarinds owe their grateful acidity to the presence of citric, tartaric, and other vegetable acids. In addition to their cooling qualities, they act as gentle laxatives, and are useful in some forms of sore-throat. The pulp mixed with salt is used as a liniment in rheumatism by the Creoles of the Mauritius. The timber is valuable for building purposes, and furnishes excellent charcoal for the manufacture of gunpowder.

Tamarisk. [TAMARIX.]

Tamarite. A Mineralogical synonym for Copper-Mica, from its occurrence at Huel Tamar.

Tamarix (Tamarisia, the people among whom it grows). A name given by botanists to some shrubs of slender growth, known as Tamarisks. They are clothed with very small green leaves and long spikes of pink flowers, the natural country of which seems to extend from Spain to Delhi, occupying a band of ten or twelve degrees of latitude. They represent the order *Tamaricaceæ*.

The Tamarisk will bear exposure to any degree of wind. The stems and leaves abound in sulphate of soda, and a species either closely allied to or identical with the common Tamarisk produces in Arabia a substance considered by the Bedouins a great dainty, and called by them *mann* or MANNA. In the month of June it drops from the branches upon the fallen twigs and leaves, which always cover the ground beneath the tree, and being collected and cleaned is eaten with bread. Some travellers suppose this substance to be not an exudation from the tree, but the produce of an insect which infests the

Tamarisk. It is said to be most abundant in rainy seasons.

Tambac. [TOMBAC.]

Tambookie Wood. A hard handsome wood, which, when powdered, is used by the South African Zulus as an emetic.

Tambourine (Fr. tambourin). A musical instrument of percussion of the drum species, being a cylinder of about six inches long in which bells are suspended. It is covered at one end with parchment, after the fashion of a drum.

Tammela Tantalite. A variety of Tantalite from Tammela, in Finland, containing only a small quantity of tin.

Tamping. A term used by miners to express the filling up of a hole bored in a rock for the purpose of blasting.

TAMPING. In Military Mining, packing with rammed earth, sand-bags, &c. that part of the mine nearest to the charge. This is intended to increase the effect of the charge.

Tamus. Of this, the only European representative of the order *Dioscoreaceæ*, one well-known species, *T. communis*, is the Black Bryony of our hedges. It has thick tuberous roots, sending up annual twining stems, which grow to a great length, and climb over bushes and hedges. The large fleshy roots of the Bryony contain an abundance of acrid clammy juice, and were formerly used in the preparation of stimulating plaisters. Rustic practitioners employ them for removing the discoloration of the skin from bruises. The fruits steeped in gin are a popular remedy for chilblains.

Tang or **Tangle.** The common name of *Laminaria digitata*. The Orkney kelpmen give this name exclusively to the narrow-fronded variety, while the ordinary form is called Cuvy. What is called Black Tangle is *Fucus vesiculosus*.

Tangencies (Lat. tango, *I touch*). In the ancient Geometry, the *problem of tangencies* or *tactions* was one of the six branches of the geometrical analysis created by Apollonius of Perga. Its general object was to describe a circle passing through given points, and touching straight lines or circles given in position, the number of data in each case being, of course, limited to three. Of the treatise of Apollonius some lemmas only were preserved in the mathematical collections of Pappus. From these collections the treatise was restored by Vieta, of whose restoration there is an English translation by Lawson, with the addition of a supplement by Fermat, on Spherical Tangencies. The principal cases of the problem of plane tangencies are given, and neatly demonstrated, in Leslie's *Geometrical Analysis*.

Tangent (Lat. tango, *I touch*). In Geometry, a right line passing through two consecutive points of a curve. If we conceive a right line to rotate around one of its intersection points with the curve until another intersection point comes to coincide with the first, it will in the last position become a tangent. Unless the point on the curve be a MULTIPLE POINT, the tangent at it will be unique; and, unless the curve be of the second order, it will cut the curve again in points which are termed TANGENTIALS. If two of these tangentials coincide with each other, the tangent is termed a DOUBLE TANGENT. A tangent is termed *stationary* when one of the tangentials coincides with the point of contact. [TANGENT, STATIONARY.]

To find the equation to the tangent is a simple problem in the differential calculus which is explained in all text-books. If the equation to the curve, rendered homogeneous by the introduction of a third co-ordinate, z, be $u=0$, the homogeneous equation of the tangent at a point (x_1, y_1, z_1) will be

$$x\frac{du_1}{dx_1} + y\frac{du_1}{dy_1} + z\frac{du_1}{dz_1} = 0,$$

where u_1 denotes what u becomes when x, y, z are replaced by x_1, y_1, z_1. This equation, it will be seen, is that of the *polar line* of x_1, y_1, z_1. [POLES AND POLARS.] Euclid has shown that no straight line can be drawn between a circle and its tangent which does not cut the circle. This property is true of all other curves, and the contact of a curve with its tangent is called a contact of the first order. [CONTACT.]

When rectangular co-ordinates are employed, the term *tangent* is frequently applied to that portion thereof which is intercepted between the point of contact and the abscissa axis. The intercept, on this axis, between the ordinate and the tangent is termed the SUBTANGENT. When polar co-ordinates are used, the portion of the tangent which is intercepted between the radius vector to its point of contact and a perpendicular to this radius vector through the pole, is termed the *polar tangent*; it is expressed by $\frac{r\,ds}{dr}$, where ds denotes the arc-element.

In *Trigonometry*, the ratio of the perpendicular to the base of any right-angled triangle is termed the *tangent of the angle* at the base; and by the *tangent of an arc*, in earlier works on trigonometry, is meant the portion of the tangent at one extremity of the arc intercepted between the radii to the two extremities.

Tangent, Inflectional. [INFLECTIONAL TANGENTS.]

Tangent Plane. In Geometry, it is shown that the tangents at any ordinary point on a surface to the several plane sections through that point all lie in one plane. This is called the *tangent plane* to the surface at the point in question. If the Cartesian equation $U=0$ of the surface be rendered homogeneous by the introduction of a fourth co-ordinate, u, the homogeneous equation of the tangent plane at the point x_1, y_1, z_1, u_1 will be

$$x\frac{dU_1}{dx_1} + y\frac{dU_1}{dy_1} + z\frac{dU_1}{dz_1} + u\frac{dU_1}{du_1} = 0,$$

where $\frac{dU_1}{dx_1}, \frac{dU_1}{dy_1}$ &c. denote what $\frac{dU}{dx}, \frac{dU}{dy}$ &c. become when x, y, z, u are replaced by x_1, y_1, z_1, u_1. In general the tangent plane intersects the surface in a curve which has the point of contact for a double point. [INDICATRIX.] The two tangents to this curve at the double point are termed INFLEXIONAL TANGENTS. Should the latter coincide, the curve will have a cusp, and at an adjacent point thereto will coincide with the original tangent plane, which is then said to be *stationary*.

Tangent Scale. [SIGHTS FOR ORDNANCE.]

Tangent Screw. An endless screw, applied as a tangent at the edge of a toothed wheel, with which the screw gears, and by each revolution of the screw the wheel is turned on its axis the distance of one tooth of the wheel from the next one. Screws of this kind are useful for minute adjustments, as a considerable amount of rotation in the screw gives but a small amount of rotation to the wheel.

Tangent, Stationary. In Geometry, a tangent which meets a curve in *three* consecutive points. The point of contact is called a *point of inflexion*. [INFLEXION, POINT OF.] A curve being regarded as the envelope of a line which turns continually around one of its own *points* (itself in motion), this line becomes a *stationary* tangent when, previous to turning in an opposite direction, its motion is for an instant arrested.

Tangents, Method of. A method, based on kinematical principles, and devised by Roberval in the seventeenth century, for constructing the tangent at any point of a curve. It consists simply in the composition of the several velocities which the generating point is known to possess; for the direction of the resultant velocity will obviously coincide with the required direction of the tangent. Thus the generating point of a parabola may be regarded as having two equal velocities, one along the focal radius vector, and the other parallel to the diameter. Hence we may conclude that the direction of the resultant velocity, in other words, the tangent, will bisect the angle between the radius vector and a parallel to the axis—a well-known theorem. Roberval's method, though still occasionally used, is interesting chiefly as being the forerunner of Newton's more elaborate method of fluxions. An account of it, written by one of Roberval's pupils and containing numerous applications, will be found in the *Mémoires de l'Acad. Roy. des Sciences*, tome vi. Paris 1730.

One of the earliest uses which was made of the differential calculus was to find the positions of tangents to curve lines; and hence the calculus itself, in its early period, was often denominated the *method of tangents*. When the equation of the curve is given, it is easy to find the tangent at any point, as only a simple differentiation is required in addition to the ordinary operations of algebra; but the inverse problem, to determine the equation of the curve when its subtangent at any point is given, requires an integration, and is consequently, in general, attended with much greater difficulty. The first problem was called the *direct*, and the second the *inverse* method of tangents. The terms are synonymous with *differential* and *integral calculus*.

Tangentials. The tangentials of a point on a curve are the intersections with the curve of the tangent at that point. Every point on a curve of the n^{th} order has $n-2$ tangentials. In the case of a cubic, each point has but one tangential, and the tangentials of three points in the same right line are themselves in a right line. [TRANSVERSALS.]

Tanghicin or **Tanguin.** A crystallisable neutral principle said to possess narcotic properties, extracted from the kernel or seed of the *Tanghinia venenifera*, a native of Madagascar. The extract of the seed has been called *Tanginine*.

Tanghinia (Tanghin, its Malagassy name). The Tanghin, or Tanquen, is the only plant belonging to a genus of the *Apocynaceæ*, named *Tanghinia*, confined to Madagascar. *T. venenifera* is a tree with smooth alternate thickish leaves, clustered towards the points of the branches, and bears large terminal cymes of flowers, having a salver-shaped corolla with rose-coloured lobes. The ovary is double, with a long style and thick stigma, but in general only one comes to perfection, forming an ellipsoid fruit, somewhat pointed at the ends, and having a smooth purplish skin tinged with green, containing a hard stone surrounded by a thick fibrous flesh. In Madagascar the natives formerly placed unbounded confidence in the poisonous seed of the Tanghin as an infallible detector of guilt. The portion used as an ordeal is the seed, which is pounded, and a small piece is swallowed by each person to be tried: those in whom it causes vomiting escape, but to those whose stomachs retain it it is quickly fatal, and their guilt is then held to be proven. [ORDEAL BEAN.]

Tanistry (Gael. tanais-teachd). An ancient Irish custom of descent, defined as 'descent from the oldest and worthiest of the blood.' (Sir J. Davies's *Cases before the Irish Judges*, 1762.)

The name, however, is alone local. The custom of tanistry is universal in rude societies, where the security of the administration will not permit a minor or incompetent person to assume the reins of government. The elections of the Merovingian kings in France, of the Gothic kings in Spain, of the Anglo-Saxon kings in England, and, for some time, even of their Norman successors, was determined by the worthiness of any member of the royal house. The principle of an indefeasible hereditary right, resting in one individual, is of later origin. But the worst feature in the Irish custom was its concomitant custom of gavelkind, by which a redistribution of the property possessed by the sept or clan was made on the decease of the

chief; a custom wholly incompatible with the growth of civilisation and wealth.

Tank (Sansc. tanghi, Port. tanque). In Gardening, a cistern, or reservoir, made of stone, slate, timber, or some other material, used in collecting and preserving water during a scarcity or drought. Tanks are sometimes built in the ground, and lined with lead or cement. (Loudon's *Encyc. of Gardening*, p. 603.)

TANK. In the Navy, a case of sheet iron about four feet square, and containing about two tons. Bilge tanks are of various forms, in order to employ the vacant spaces near the sides in small vessels. Wooden casks were formerly employed; but iron tanks have for many years been used in the navy, from their incomparable superiority over casks in keeping the water sweet.

Tannenite. A double sulphide of bismuth and copper found at Tannenbaum in Saxony.

Tanner's Bark. The bark of oak, chestnut, willow, larch, and other trees, which abounds in tannin, and is used by tanners for preparing leather. After being exhausted of the tanning principle by being chopped into small pieces, or bruised, and steeped in water, it is laid up in heaps to dry, and in this state is sold to gardeners for the purpose of producing artificial heat by fermentation in pits or beds, in bark-stoves or pits. [STOVE.]

Tannic Acid. *Tannin.* The pure astringent principle of vegetables, upon which their power of converting skin into leather depends. Its leading character is its property of producing a dense whitish precipitate in a solution of animal jelly, such, for instance, as isinglass. The action of astringents upon persalts of iron has given rise to its distinction into two varieties; the first changing them to deep blue or black, the second to green. The tan of galls, oak-bark, grape-seeds, &c. possesses the former property; that of catechu and tea the latter.

Several varieties of tannic acid are distinguished, as to the sources whence they are obtained, as *gallotannic* acid from gall-nuts, *quercitannic* from oak-bark, *mimotannic* from catechu, &c., each having certain peculiarities, but all agreeing in forming insoluble compounds with gelatine, and producing a black colour with persalts of iron. Tannin occurs in an infinity of plants, and may be detected in their infusions by the tests just mentioned, and by their astringent taste. Gallotannic acid, obtained by the action of washed ether upon powdered galls, may be taken as a specimen of tannin in its purest form; it is yellowish, amorphous, very soluble in water, reddens litmus, and tastes intensely astringent; its aqueous solution absorbs oxygen from the air, and passes into *gallic acid*; when boiled with dilute sulphuric acid, it is resolved into gallic acid and glucose, as shown in the following equation:—

$$\underbrace{C_{54}H_{22}O_{34}}_{\text{Tannic acid.}} + \underbrace{8HO}_{\text{Water.}} = \underbrace{3C_{14}H_6O_{10}}_{\text{Gallic acid.}} + \underbrace{C_{12}H_{12}O_{12}}_{\text{Glucose.}}$$

By digesting powdered charcoal in nitric acid, and carefully evaporating the solution, Mr. Hatchett obtained a brown astringent substance which precipitated gelatine, and which he called *artificial tannin*. (*Phil. Trans.* 1805, 1806.) The uses of tannin are numerous and important: among them may be mentioned especially the manufacture of leather, the formation of black dyes, of writing ink, and its medicinal and dietetic applications.

Tannin. The astringent principle or tannic acid of the bark or galls of the oak and other trees [BARK], of the leaves of sumach [RHUS], and of other vegetable productions, used for tanning leather. The name has reference to its property of combining with the skins of animals, by which they are prevented from becoming putrid, and rendered impervious to water. The process by which this is effected is called *tanning*.

Tansy (Fr. tanaisie). The common name for *Tanacetum vulgare*, a perennial herb of the Composite family. The herb and flower-heads of this plant, used sometimes as a kind of medicinal pot-herb, have a disagreeable though somewhat aromatic odour, and a strong nauseous bitter taste. A small portion is sometimes added to omelets, and Tansy wine enjoys some reputation among rustic practitioners as a stomachic. The curled-leaved variety is a very beautiful plant for garnishing dishes.

Tantalite. Native tantalic acid. It occurs crystallised in iron-black quadrangular prisms, which are mostly incomplete and variously modified. The chief localities where it is found are Finland; Chanteloube, near Limoges, in France; Bodenmais, in Bavaria; and Haddam, in Connecticut. Certain varieties from Finbo, Broddbo, and Kimito, contain a large quantity of oxide of tin. [CASSITEROTANTALITE.]

The metal Tantalum was discovered by Ekeberg in specimens from the last-mentioned locality.

Tantalum. A rare metal, formerly supposed to be identical with columbium. It is found in TANTALITE and YTTRO-TANTALITE.

Tantalus (Gr. Τάνταλος). The myths of Tantalus and Ixion may be considered together, as exhibiting, throughout, the working of the same ideas. These myths exist in many versions, the chief points in each being the following.

Tantalus is represented by some as a son of Zeus, his wife being Euryanassa. His children are Pelops, Broteas, and Niobe, and he is said to have been king of Lydia, of the Phrygian Sipylus, or of Argos. Admitted to the banquet-table of Zeus, he was made acquainted with the secret counsels of the father of gods and men. These, contrary to his promise, he made known, and for this offence he was punished by being placed in the midst of a lake, the waters of which turned to slime when he stooped to drink of them, and under branches laden with fruit, which vanished when he sought to grasp them, while over his head a huge rock suspended in the air threatened constantly to destroy him. Another version relates that, like the sons of

Lycaon, Tantalus served up to Zeus at a banquet the body of his son Pelops, while another says that he stole nectar and ambrosia, and gave them to his people. (Pindar. *Ol.* i. 98.) It is also related that he was intrusted by Pandareos with the care of the dog which had guarded the infant Zeus in Crete, but that when Pandareos demanded back the dog, Tantalus declared that he had never received it.

According to one tradition, Ixion was a son of Phlegyas, and the husband of Dia, the daughter of Hesioneus, to whom he refused to give the rich presents which he had promised for the gift of his child in marriage. When Hesioneus insisted on the performance of the contract, Ixion invited him to a banquet and then let him fall into a pit full of fire. (Diodorus iv. 69.) Zeus alone of all the gods could be induced to purify Ixion from this murder, and Ixion rewarded his kindness by attempting to win the love of HERA. But Zeus placed in his way a phantom resembling Hera, and by this phantom Ixion became the father of the Centaurs. As a punishment for his treachery to Zeus, he was bound on a blazing cross of four limbs, which rolls round in the air for ever and ever. (Pind. *Pyth.* ii. 73.)

Thus these two myths closely resemble each other, while the chief incidents of each recur in other legends, in which the names and details point to mythical phrases indicating the action of the sun. Tantalus lives in a golden palace like that of Helios, from which PHAETHON went forth on his ill-starred journey. His wisdom is the wisdom of Phœbus Apollo (*Hymn to Hermes*, 534), received immediately from Zeus, and which he may not impart even to HERMES. His frequent communings with Zeus are paralleled by the daily visits of Helios to the dizzy heights of heaven. His theft of nectar and ambrosia for the benefit of his friends answers to the stealing of the fire by PROMETHEUS; and in the gifts thus bestowed by Tantalus on his people we see the wealth which the sun brings from the sky and lavishes on the children of men. The hound given to him in pledge by Pandareos is the hound of Artemis, which reappears in the tale of PROCRIS; it is the mighty hound of the gods (the wind), who chases the clouds over seas and mountains, always felt but never seen, and which the sun cannot, therefore, restore. The slaughter of Pelops, although as repulsive as the legend of Erichthonios (Apollodorus iii. 14, 6), may, like that tale, be traced to similar mythical phrases. The warmth of the sun brings to light the fruits of the earth, which is his bride; his raging heat kills his offspring, which is offered up as a scorched and withered victim in the eyes of ZEUS (the sky). His punishment accords not less closely with the meaning of the old mythical expressions. Hermes, who kindles a fire and roasts the sacrifice, cannot appease his hunger, for the wind cannot eat of that which the fire devours. So, like Tantalus, the sun may look on the fruits of the earth or on the clear rivers; but if he stoops to drink and brings his lips near to the laden branches, his breath withers the fruits and dries the streams as in a time of drought, and thus, in the words of the Homeric poet (*Odyss.* xi. 187), only black mud and gaping clay remain in place of flowing water, and the leaves shrivel up beneath the fierce glare of noonday. The rock which hangs over Tantalus and threatens to crush him is the Cyclops Polyphemus [CYCLOPES], and the Theban SPHINX, which broods ominously over the city of ŒDIPUS, both being images of the thunder-cloud, which gathers into the shape of mountains, and remains motionless in the sky until its wrath breaks forth in the storm. [VRITRA.]

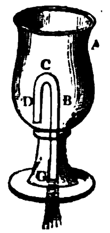
The punishment of Tantalus, which has given rise to the verb *tantalise*, answers to the disappointment of Orpheus when he turns too soon to embrace Eurydikê, who is following him from Hades. In the restoration of Pelops to life we see the operation of that power which is exercised at will by the Colchian MEDEIA. Like that of Eurydikê, the name of Euryanassa, the wife of Tantalus, belongs to that vast class of names which denote the broad flush of light which overspreads the sky at dawn.

Phrases of the same import with those which gave shape to the legend of Tantalus account for the myth of Ixion. Like the name ORPHEUS, the name Ixion is explained by a comparison with the Sanscrit Akshivan, the being who turns on a wheel (Gr. ἄξων, Lat. axis, *axle*). Of this identification, M. Bréal ('Le Mythe d'Œdipe,' *Revue Archéologique* for Sept. 1863) says that no doubt can remain when in Vedic hymns we read of the wheel of the sun, and the battle waged by Dyaus (ZEUS, the heaven) to snatch it from the grasp of night. Thus Ixion loves Hera, the queen of the pure air, as Indra loves the Dawn and Phœbus loves DAPHNE. In his children the Kentaurs [CENTAURS] are seen the Sanscrit Gandharvas, the bright clouds in whose arms the sun reposes as he journeys through the sky. The treasure-house of Ixion answers to the golden palaces of Tantalus and Helios. These are represented as flaming with gold: the treasure-chamber of Ixion is a gulf of fire which scorches the body of Hesioneus, when he insists on the fulfilment of Ixion's promise. The darkness and gloom which follows this deed is a time of plague and drought, answering to that which is brought about by the efforts of Tantalus to appease his thirst. When pardoned for this offence, Ixion incurs deeper guilt, and each day his love for Hera becomes warmer, as the summer sun gains a greater power; but when he seeks to embrace her, she vanishes like Daphne from Phœbus or Eurydikê from Orpheus, and Ixion himself is bound to that four-spoked wheel which figures to the eye the disc of the sun at noontide.

Like Peleus, Ixion has horses which cannot die, and which under the names of Xanthos and Balios are yoked to the chariot of Achilleus. The name of his father Phlegyas (φλέγω) is significant of burning heat, and the withholding of the bridal gifts after the marriage of Dia

corresponds with an incident in the story of Hesionê, where Laomedon, playing the part of Ixion, refuses to give to Heracles the horses which he had promised to him for the rescue of his daughter.

Tantalus's Cup. A philosophical toy which amusingly exhibits the principle of the siphon. Into a hole in the bottom of a cup A the longer leg of a siphon B C D is cemented, so that the end D of the shorter leg nearly touches the bottom of the cup within. When water is poured into the cup, it rises in the shorter leg of the siphon until it reaches the level of the top of the bend at C, when it flows over into the larger leg, and is carried off at G; so that if water is not supplied to the cup faster than it is drawn off by the siphon, the cup will be emptied.



To form the toy, the legs of the siphon are concealed by the hollow figure of a man whose chin is on a level with the bend of the siphon; so that the figure stands like Tantalus in the fable—up to the chin in water, but unable to quench his thirst.

Tantipartite Function. This term denotes a function which is linear with respect to several distinct sets of quantities. Thus, a determinant is a tantipartite function, the elements in each line or column constituting a set. When there are only two sets of facients, the function is said to be *lineo-linear*; an example of such a function, x, y, and x', y' being the two sets of facients, is

$$axx' + bxy' + cx'y + dyy'.$$

Tanystomes (Gr. τανύω, *I stretch*, and στόμα, *a mouth*). The name of a family of Dipterous insects, comprehending those which have a projecting proboscis, with the last joint of the antennæ undivided.

Tanystropheus (Gr. τανύω, and στρέφω, *to twist*). A genus of Sauropterygian Reptilia, in which the longitudinal diameter of the vertebræ was greater than in any other vertebrate animal, recent or fossil.

Tap Root. The main root of a plant, which strikes perpendicularly into the soil. It is sometimes succulent with few fibres, as in the carrot and radish; sometimes woody with many horizontal ramifications, as in the oak-tree. This tap root grows in advance of the other roots, and acts as a sort of anchor to keep the tree firm in the ground; hence, in transplanting trees or shrubs, it should never be divided.

Tap-rooted. Having a large simple conical root, which forms a centre round which the divisions are arranged.

Tape-worm. [Tænia.]

Taper (A.-Sax.). In Botany, this term is applied to parts the opposite of angular; usually employed in contradistinction to that term, when speaking of long bodies. [Terete.]

Tapestry (Fr. tapisserie, from tapis, Lat. tapete). An ornamental figured textile fabric of worsted or silk for lining the walls of apartments. Of the earlier manufactories of this kind were those of Arras, Brussels, Antwerp, and Valenciennes. Those of Arras were executed chiefly in wool with a little hemp and cotton, but without silk or gold or silver thread. The best known tapestry is now produced at the Gobelins royal manufactory near Paris.

In Painting, the word *tapestry* is applied to a representation of a subject in wool or silk, or both, worked on a woven ground of hemp or flax.

Tapioca. The prepared starch of the root of the *Manihot utilissima*, employed as a diet for invalids. The root abounds with a milky juice, which is poisonous, but which deposits an inert starch when diffused through water. It is called *Cassava*, and is rendered harmless by boiling.

Tapir. The name of a genus of Perissodactyle Mammals, of which three existing and several extinct species have been determined. Of the existing species one is a native of Sumatra, the other two of South America. They have a short proboscis; four toes on the fore foot, and three toes on the hind foot.

Tar (A.-Sax. tare, Ger. theer). A dark brown or black viscid liquid obtained in the destructive distillation of organic matters. There are three principal kinds of tar: *wood tar*, obtained in the manufacture of wood vinegar and wood spirit by the destructive distillation of wood; *Stockholm tar*, largely used in the arts, as in shipbuilding, &c., which is obtained by a rude distillatio per descensum of the roots and other useless parts of the resinous pine; and *coal tar*, obtained during the destructive distillation of coal in the manufacture of coal gas. The tars are extremely complex mixtures. Wood tar yields on repeated fractional distillations paraffin, eupion, picamar, kapnomor, cedriret, and creosote. The residue left in the retort constitutes pitch, and from it the two hydrocarbons chrysen and pyren have been obtained. Coal tar by distillation furnishes carbolic acid or phenol; cresylic alcohol; xylylic alcohol; the liquid hydrocarbons benzol, toluol, xylol, cumol, and cymol; the solid hydrocarbons naphthalin, paranaphthalin, and paraffin; rosolic and brunolic acids; and the basic compounds aniline, cespitine, pyridine, picoline, lutidine, collidine, parvoline, coridine, rubidine, viridine, leucoline, cryptidine and pyrrol.

In former days, *tar water*, under the authority of Bishop Berkeley, was considered as a universal remedy, more especially in rheumatic, syphilitic, and cutaneous affections. The bishop's practice was ridiculed with much point and effect in a pamphlet by Mr. Reeve, entitled *A Cure for the Epidemic Madness of Drinking Tar Water*, in which he says: 'In your younger days, my lord, you made the surprising discovery of the unreality of matter, and

now in your riper age you have undertaken to prove the reality of an universal remedy; an attempt to talk men out of their reason did of right belong to that philosopher who at first tried to reason them out of their senses.'

Tar, Mineral. A viscid variety of Bitumen, much resembling Petroleum.

Tara. An Indian name for *Corypha Taliera*, the Talipat Palm.

Taranis. In Mythology, a Celtic divinity, confounded by Latin writers with their Jupiter. (Lucan, *Phars.* i. 446.)

Tarantella. [Tarantula.]

Tarantula (so called from Taranto in Sicily). The name of a Fabrician genus of pedipalpous pulmonary Arachnidans, infesting the torrid regions of Asia and America. The group is now divided into the genera *Phrynus* and *Thelyphonus*. The term is also applied to a genus of spiders found in some parts of Sicily, whose bite produces a train of symptoms long believed to be curable only by music. From this word is derived the term *tarantella*, the national dance of the Sicilians.

Taraxacin. A crystallisable bitter principle contained in the juice of the root of dandelion (*Taraxacum dens leonis*).

Taraxacum. The Dandelion, one of our most familiar weeds, is the type of this genus of Composites. This plant, the *T. dens leonis*, is universally found in Europe, Central Asia, North America, and the Arctic regions, and varies much in stature and appearance, according to the locality in which it grows. The rootstock is extensively used in medicine as an aperient and tonic, especially in liver-complaints. It has also diuretic properties, and may be used in the same manner as chicory. The leaves are eaten by cattle with advantage, and are greedily devoured by rabbits.

The bright yellow flowers of this plant open in the morning between five and six o'clock, and close in the evening between eight and nine—hence this was one of the plants selected by Linnæus to form his floral clock.

Tardigrades (Lat. tardus, *slow*; gradior, *I march*). A family of edentate Mammals, comprising those which are remarkable for the slowness of their motions when upon the ground, as the sloths.

Tardo (Ital. *slow*). In Music, a term denoting that the movement to which it is affixed is to be performed slowly. It is nearly the same in signification as *largo*.

Tare. In Agriculture, the name of the common Vetch (*Vicia sativa*).

Tare. In Commerce, tare is a deduction made from the weight of goods by taking into account the weight of the packing. It is said to be *real*, when the true weight of such a packing is estimated; *average*, when a few similar cases are taken, and the average estimated as equal on all the cases; *customary*, when a uniform weight is taken as the rule of the place. Some of the weights found in England, as the hundred of 112 lbs. and probably the pound of 16 ounces, were originally inclusive of the tare. The hundred passed through another stage when it was reckoned at 108 lbs.

Targum. A Chaldee word, denoting, generally, the Chaldee, or more properly Aramaic, versions of the Old Testament; the two best known being those of Jonathan Ben Uzziel (or rather the Pseudo-Jonathan), an author who wrote a paraphrase or commentary upon the Greater and Lesser Prophets, about B.C. 30; and of Onkelos, upon the Pentateuch, which is considered the most valuable of all, and is referred to the first century of our era. (*Ency. Met.*; see also the treatise on this subject, under the head 'Versions,' by Mr. Emanuel Deutz, in Smith's *Dictionary of the Bible*.)

Tari. The sap of *Phœnix sylvestris*, which is drunk in India either fresh or fermented.

Tariff. A table arranged alphabetically, and containing a schedule of all duties, &c. levied upon imports and exports. This name is taken from the Spanish town Tarifa, at the entrance of the straits of Gibraltar, where duties were formerly collected. The English tariff, till the reforms of Sir Robert Peel, was exceedingly lengthy, but it is now confined to very few articles. Changes in tariffs have been the prominent purposes of those acts of commercial diplomacy which have been entered upon between this and other countries of late years.

Tarnowitzite. A variety of carbonate of lime, or species of Aragonite, containing a small proportion of lead; found at Tarnowitz in Upper Silesia.

Taro. The tuberous roots of *Caladium esculentum*, *Colocasia macrorhiza*, &c.

Tarpawling or **Tarpauline.** A painted or tarred canvas cover.

Tarpeia. In Roman Mythology, the maiden who gave her name to the Tarpeian rock. According to one story, she agreed to open the gates of the city to the followers of Titus Tatius, bargaining with them that they should give her what they wore on their left arms; but they threw upon her their shields instead of the bracelets which she had desired. In another version, she wishes to deceive the Sabines, and not to favour them; while in a third legend she is described as betraying the Capitol to a king of the Gauls of whom she was enamoured, and not to a king of the Sabines. (Sir G. C. Lewis, *Credibility of Early Roman History*, ch. xi. sect. 4.)

Tarras, Terras, or **Trass.** A volcanic product of the nature of pozzuolano. Mixed with ordinary mortar, it gives the resulting material the property of setting or hardening under water. Several argillo-ferruginous minerals possess the same property, and are indiscriminately used under this term. [Pozzuolano.]

Tarse or **Tarsus** (Gr. ταρσός, *sole of foot*). In Mammalia, this word signifies the collection of small bones between the tibia and metatarsus, or those which constitute the first part of the foot. In birds, it is sometimes applied

to the third segment of the leg, which is rarely fleshy or feathered, and corresponds with the tarsus and metatarsus conjoined. In insects, it signifies the aggregate of minute joints which constitute the fifth principal segment of the leg or the foot.

Tartar (Gr. τάρταρος, *the nether world*, because it is the sediment or dregs of wine). The substance which concretes upon the inside of wine casks. It is called *red* and *white argol*, according to the wine from which it is obtained. When purified, it is often called *cream of tartar*: it is a bitartrate of potash. [TARTARIC ACID.]

Tartar Emetic. [EMETIC TARTAR.]

Tartar of the Teeth. This substance, which occasionally concretes upon the teeth, consists, according to Berzelius, of—

Salivary mucus	13·5
Animal matter soluble in muriatic acid	7·5
Phosphate of lime (earthy phosphates)	79·0
	100·0

Tartaric Acid. The acid of tartar. This acid, which in its ordinary state may be represented as = (2HO, $C_8H_4O_{10}$), is found free, and in combination, in many vegetables; its principal source is in the juice of the grape, in which it exists in the form of *tartar*, or bitartrate of potash. The acid is obtained from this salt as follows: 4 parts of it, in fine powder, are well mixed with 1 part of powdered chalk, and the mixture thrown, by small portions at a time, into 10 parts of boiling water. When the effervescence is over, the whole is stirred and left to subside. The liquid, which is a solution of neutral tartrate of potash, is then poured off the sediment, which is tartrate of lime, and a solution of chloride of calcium is added to it. This throws down an additional portion of tartrate of lime, which is mixed with the first, and having been well washed, is decomposed by dilute sulphuric acid. This forms sulphate of lime, while the tartaric acid remains in solution, and is obtained by slow evaporation. The first crystals require to be redissolved, and digested with a little purified animal charcoal until the liquid is colourless; it is then again evaporated and crystallised.

Tartaric acid is very sour; its crystals exhibit complicated forms, derived from an oblique rhombic prism. Water dissolves about 1·5 its weight at 60°, and more than twice its weight at 212°. It is also soluble in alcohol.

Tartaric acid is distinguished by the white crystalline precipitate which it produces when added in excess to solutions containing potash. If these solutions are very dilute, the precipitation is accelerated by the addition of alcohol. It is used in calico printing, and is much employed as a cheap substitute for citric acid in lemonade and in effervescent solutions.

Pasteur has shown that there are two modifications of tartaric acid. The crystals of one variety, when dissolved in water, turn the plane of polarisation to the right—*dextro-tartaric*, or the common tartaric acid. The crystals of the other variety, when dissolved in water, turn the plane to the left—*lævo-tartaric acid*. It is remarkable that when equal parts of the two acids are mixed, crystals are deposited from the mixture, which appear to be identical in properties with racemic or paratartaric acid; they have no action on a ray of polarised light.

The *Tartrates* are mostly crystallisable, and are either neutral or acid. In the neutral tartrates 2 atoms of base are combined with 1 atom of acid, as in neutral tartrate of potash, which is 2(KO), $C_8H_4O_{10}$, or in tartrate of potash and soda, = KO,NaO,$C_8H_4O_{10}$. In the acid tartrates (or bitartrates) 1 atom of water replaces 1 of the bases, as in bitartrate of potash, which is KO,HO,$C_8H_4O_{10}$. There is also an important class of tartrates in which one of the bases is a protoxide and the other sesquioxide, the salt being neutral, as in the tartrate of potash and antimony (emetic tartar), which is KO,SbO_3,$C_8H_4O_{10}$. *Tartrate of potash*, used as an aperient under the name of *soluble tartar*, forms prismatic crystals of a saline and bitter taste, soluble in 2 parts of water. *Bitartrate of potash* or *Tartar* exists in the juice of the grape, and is deposited in wine casks in the form of a white or red crystalline incrustation, called *argol* or *crude tartar*. It is purified by dissolving it in boiling water, with one-twentieth of its weight of pipeclay, which absorbs the colouring-matter, and falls as a sediment, the crystals of tartar separating afterwards upon the surface of the liquor, and upon the sides and bottom of the boiler; the term *cream of tartar* was originally applied to the superficial crust.

The acid tartrate of potash is also formed by adding excess of tartaric acid to a solution of potash: the mixture presently deposits crystalline grains, and furnishes an example of diminution of solubility by increase of acid in the salt. Upon this the use of tartaric acid as a *test* for potash depends; for soda forms an easily soluble supertartrate, and affords no precipitate.

The crystals of this salt, which are rhombic prisms, are soluble in 184 parts of water at 68°; and in 18 parts at 212°.

Tartrate of Potash and Soda is prepared by saturating the excess of acid in tartar, with carbonate of soda. It is the *Soda tartarizata* of pharmacy, and forms fine transparent prismatic crystals. This salt has long been used as a mild aperient, under the name of *Rochelle Salt* and *Sel de Seignette*, having been first prepared at Rochelle by an apothecary of the name of Seignette.

Tartrate of Lime is often found as a crystalline deposit in light white wines. It falls on dropping tartaric acid into lime-water, and is soluble in excess of the acid.

Tartrate of Potash and Antimony. [EMETIC TARTAR.]

When common tartaric acid is heated to

about 350°, it fuses and congeals on cooling into a vitreous mass, which has the same saturating power as the original acid, but which produces salts differing in crystalline form. If the heat exceed 360°, the acid becomes monobasic, but still without loss of weight, and is represented by $HO,C_8H_5O_{11}$. These isomeric modifications have been designated *metatartaric* and *isotartaric* acids: when solutions of their salts are boiled, they gradually revert to common tartrates. When the common acid is kept in fusion at about 372°, it loses half an equivalent of water, and is changed into *tartralic acid*. When the temperature of the fused acid is raised to 392°, it loses an equivalent of water, and becomes *tartrelic acid*. The tartralates and tartrelates are converted into tartrates, when boiled with water. By carefully continuing the action of heat on tartaric acid, it may be obtained *anhydrous*; it is then white, amorphous, and insoluble in cold water; but by the protracted action of water, or by boiling, it reverts to its ordinary condition, by the resumption of two atoms of water.

The relations of the anhydrous tartaric acid to its several hydrated modifications, are as follow:—

Anhydrous tartaric acid . .	$C_8H_4O_{10}$	
Crystallised tartaric acid . .	$C_8H_4O_{10}$	2HO
Metatartaric acid	$C_8H_4O_{10}$	2HO
Isotartaric acid	$C_8H_8O_{11}$	HO
Tartralic acid	$2(C_8H_4O_{10})$	3HO
Tartrelic acid	$C_8H_4O_{10}$	HO
Racemic acid	$C_8H_4O_{10}$	2HO

Tartarus (Gr. *τάρταρος*). In Greek Mythology, a son of Æther (air) and Gê (earth), and the father of Typhoeus and ECHIDNA. In the *Iliad* the name Tartarus denotes a place, closed in by iron gates, as far below HADES as heaven is above the earth. In the Platonic dialogue entitled *Gorgias*, Tartarus is the place where the souls of men pay the penalty for the evil deeds done during their lifetime on earth. [SOUL.]

Tartrates. Salts in which the tartaric acid is combined with bases. [TARTARIC ACID.]

Tartrovinic Acid. An acid composed of tartaric acid, in which an atom of water has been replaced by oxide of ethyl (C_4H_5O).

Tartuffe. A common French nickname for hypocritical pretenders to devotion. It is derived from the celebrated comedy of Molière, of which the hero is so called. Whether Molière invented it, or took it from the popular language of the time, does not appear: some say that he intended to attack the confessor of Louis XIV., Père la Chaise, whom he had once seen eating truffles with peculiar goût; and thence the name. The play was written in 1664, but not acted till 1669; great difficulties being thrown in the way of the author by the clergy and the papal legate. On one occasion it was prohibited when the curtain was on the point of rising, and Molière announced to the public its disappointment in the well-known equivocal words, 'Monsieur le président ne veut pas qu'on le joue.' When at last licensed (through the influence, it is said, of the king himself), it had a run of three months with unparalleled success. In England, this play has been made more than once to serve the popular passions of the day. Cibber translated it, and made the hero a nonjuring churchman; and the play is still acted under the name of *The Hypocrite*, in which the Tartuffe is a methodistical divine.

Tasmanite. A mineral of organic origin. It is a hydrocarbon containing a little more than five per cent. of sulphur, and occurs in the form of minute discs, which constitute from 30 to 40 per cent. of the resiniferous shale from the river Mersey on the north side of Tasmania.

Tasmannia (after Tasmann, the Dutch navigator, the discoverer of the island now called Tasmania). A genus of *Magnoliaceæ*, consisting of one Tasmanian and two Australian species, closely allied to *Drimys*. *T. aromatica*, the Tasmanian species, possesses, as its specific name implies, aromatic qualities, particularly in its bark, which so closely resembles the Winter's Bark of Magalhaen's Straits (*Drimys Winteri*), that it is substituted for it by colonial doctors. The colonists call it the Pepper-plant, and use its little black pungent fruits as a substitute for pepper. Under the microscope the wood exhibits a structure resembling that of many coniferous plants, the fibres being marked with similar circular discs.

Taste (Fr. tâter; Ger. tasten; akin to Lat. tango, tactum, *to touch*). That power of the mind which is concerned with the beautiful, both in nature and of art. In the Latin language, the same metaphor obtained a very wide application, and the term *sapientia* was employed to signify quickness and correctness of judgment generally. Shaftesbury's use of the term is nearly as extensive, being applied by him to manners, morals, and government, and to wit, ingenuity, and beauty. In its modern use it is restricted to those objects which fall within the province of imagination. As applied to the Fine Arts, taste must be supposed to mean an intellectual perception of any object, blended with a distinct reference to our sensibility of enjoyment or dislike.

Coleridge defines the term *taste* as a metaphor taken from one of the mixed senses, and applied to objects when we would imply the coexistence of an immediate personal dislike or complacency. Now, by the constitution of man's nature, every exertion of human activity in the pursuit of the good, the beautiful, and the true, combines a sense of pleasure or the contrary with the perception of their respective objects; and this fact would justify the widest application of the metaphor. While, however, in the case of the true, this coexistent pleasure has not received any distinctive appellation, and while conscience, as comprehending the sense of approbation and disapprobation, is characteristically applied to the moral energy, taste has been confined to the perception of beauty and the accompanying gratification.

But by directing attention exclusively to this element of pleasure, the term has led to a very inadequate conception of the true nature of the faculty which it designates. Thus Hutcheson (*Inquiry into the Idea of Beauty and Virtue*) maintains that the faculty is peculiar, that beauty strikes at first sight, and that knowledge the most perfect will not increase the pleasure to which it gives rise; and, lastly, that all the diversity of sentiments excited in different minds by the beautiful arises solely from the modifications of the sense by association, custom, example, and education. Among the advocates of the theory of a moral taste we may reckon Hume, Akenside, Blair, Lord Kames, and Beattie.

Blair defines taste to be the power of receiving pleasure from the beauties of nature and art; while Akenside describes it as 'certain internal powers feelingly alive to each finer impulse.' Beattie (*Essay on Poetry and Music*) supposes taste to have its origin in a mutual harmony and sympathy between the soul in its first formation and the rest of nature. In the *Essay on the Delicacy of Taste*, Hume talks of it as a natural sensibility; while in the *Essay on the Standard of Taste*, he seems to admit of no other criterion than the decisions of a due and sufficiently extensive experience. Lastly, Lord Kames declares a taste in the fine arts to be nearly allied to the moral sense; but yet, like morals, capable of being raised to a rational science by an examination of the sensitive branch of the human constitution, and an enumeration of the objects which are either agreeable or disagreeable by nature.

But taste is not only a sensitive, it is also a cognitive faculty. When a beautiful object is presented to the mind, not only does it make on it an impression of pleasure, but the mind in the first place passes judgment upon it, and declares it to be beautiful, i.e. conformable to a standard called the beautiful. In this complex operation of taste, the judgment is the antecedent, and the pleasure the consequent. When the impassible judgment has passed sentence upon the object, then the sensibility is awakened to certain sentiments, which are, as it were, the echo of the reason. (Cousin, *Sur le Vrai, le Bien, et le Beau.*)

The same conclusion will follow from an examination of some of the principal definitions of beauty. According to St. Augustine (*Ep.* 18), 'unity is the universal form of beauty;' and to Malespina (*Delle Leggi del Bello*), 'beauty consists in unity, multiplicity, and propriety.' De Crousaz (*Traité du Beau*) makes beauty to consist in variety, unity, regularity, order, and proportion. Winckelmann and Sulzer agree also in making unity and multiplicity to be essential constituents of the beautiful. And, lastly, the definition of beauty in the Italian schools of painting, was, 'il più nell' uno'—variety in unity; which is nearly identical with Hutcheson's explanation of it—uniformity in variety.

A few definitions of beauty remain to be noticed, which apparently favour the theory of Hutcheson. According to Burke (*On the Sublime and Beautiful*) and Price (*Essay on Beauty*), beauty consists in such qualities as induce in us a sense of tenderness and affection. Alison declares that the qualities of matter are neither beautiful nor sublime in themselves, but only such so far as they are signs or expressions of qualities capable of producing emotion. Wieland makes beauty to consist in the unity of an *agreeable* variety; and Kant teaches that the beautiful pleases irrespectively of any idea of utility, or of any conception of design, simply by the correspondence of the object and the sensitive organ.

The emotions of taste are usually distinguished into those of the sublime and beautiful; but Dugald Stewart seems with justice to have denied the existence of any intrinsic difference between them. According to Burke, indeed, the terrible is a fruitful source of the sublime; and this idea does not seem capable of being made an ingredient of the beautiful. In the same way, on the other hand, there are ideas eminently beautiful which can never give rise to an emotion of sublimity. Nevertheless this does not constitute an essential difference between the two. It is with reference to their several effects upon the imagination that they may perhaps be most correctly distinguished. Considered in itself, a beautiful object ought to present the greatest possible unity combined with the greatest possible variety; and considered in its effect upon the mind, its beauty consists in the free, facile, and harmonious play of the imagination. On the other hand, the imagination is lost and overpowered in the contemplation of the sublime, which in its infinity presents at once unity and variety.

Tasto. In Music, a term used in conjunction with *solo*, to signify that the instruments which can accompany by chords are to play only single sounds till the direction is contradicted by the word *accordo* or *accompanimento*.

Tatta (Indian). A bamboo frame or trellis, over which water is suffered to trickle with a view of cooling the air as it enters the windows or doors.

Tattie. An Indian name for window or door screens made from split bamboo.

Tattooing. The art of puncturing the skin and inserting in the slight wounds thus made a coloured fluid or powder so as to produce a permanent stain. It is an ancient custom adopted by savage and by civilised nations. The device to be imprinted is first drawn or stamped upon the part; the lines are then pricked out by a pointed wire, and gunpowder, Indian ink, or some other colouring matter, immediately rubbed over the punctures so as to insinuate itself into the cutis, where it becomes indelible. (*United Service Mag.* 1844, p. 495.)

Taurin. A crystalline substance obtained by the transformation, under the influence of

acids or alkalies, of Taurocholalic acid, one of the constituents of bile. It may also be prepared by the action of heat upon isethionate of ammonia. Its composition is $C_4H_7NO_6S_2$.

Tauriscite. A mineral isomorphous with Epsomite, from Windgalle in the Canton of Uri (the *pagus Tauriscorum*, whence the name).

Taurocholalic Acid (formerly called *choleic acid* and *bilin*). A constituent of bile. It has not been obtained in the pure state, but from its decompositions the formula has been inferred to be $C_{52}H_{44}NS_2O_{13}HO$.

Taurus (Lat. *the Bull*). In Astronomy, the second in order of the twelve zodiacal constellations. There are several remarkable stars in this constellation: Aldebaran, of the first magnitude, in the eye; the well-known cluster called Pleiades in the neck; and the Hyades in the face. [CONSTELLATION; ZODIAC.]

Taut. In Sea language, tight, neat, properly ordered, prepared against emergency.

Tautochrone (Gr. ταὐτό, *the same*, and χρόνος, *time*). In Mechanics, a curve line, having this property that a heavy body descending along it by the action of gravity will always arrive at the lowest point in the same time, wherever the point from which the body begins to fall be taken in the curve. Huygens first showed that this property of *tautochronism* belonged to the common cycloid when the motion takes place in a vacuum, and gravity is supposed to act in parallel straight lines. [CYCLOID.] Newton and Hermann also determined the tautochrone in a vacuum, when gravity is supposed to be directed towards a given centre. Newton likewise showed that the cycloid is also the tautochrone in a resisting medium, when the resistance is proportional to the velocity (*Principia*, b. ii. prop. 26); and Euler first determined the nature of the tautochronous curve when the resistance is proportional to the square of the velocity. (*Mechanica*, vol. ii.; Joh. Bernoulli, *Opera*, vol. iii.)

Tautolite. A mineral resembling Hyalosiderite, found in volcanic rocks, near Lake Laach. The name is an abbreviation of Tautometrolite (Gr. ταὐτό, *the same*; μέτρον, *a measure*, and λίθος, *stone*) which has reference to the resemblance of the measurements of the angles of the crystals to those of Chrysolite and other analogous minerals.

Tautology (Gr. ταὐτολογία). In Rhetoric, a vicious diction, by which the same idea is expressed in two or more different words or phrases, apparently intended to convey different meanings.

Tavernicus. The third great officer of state in the Hungarian monarchy (after the Palatine and the Ban of Croatia), analogous to the treasurer, and in some respects to the high chamberlain, of other European monarchies (Tavernicorum Regalium Magister). The origin of this purely Hungarian title has been the subject of much dispute. (Viroszil, *Staatsrecht des Königreichs Ungarn.*)

Tawing (A.-Sax. tawinn). The art of preparing certain kinds of leather by imbuing the skins with saline, oily, and other matters. [LEATHER.]

Taxaceæ (Taxus, one of the genera). A natural order of Gymnosperms, by some, however, regarded as a sub-order of *Coniferæ*, from which it is chiefly distinguished by the fruits not being collected in cones, and by each ovule growing singly, unprotected by hardened scales. The Yew-tree is the type of the group. [TAXUS.]

Taxatio Ecclesiastica. A name given to several public records. The oldest is that of Norwich, made in 1253, for the purpose of assessing the first-fruits and tenths of ecclesiastical benefices; sometimes called Pope Innocent's valor, that pontiff having made a present of these profits for three years to Henry III. All taxation was regulated by this assessment until the reign of Henry VIII., when the *Valor Ecclesiasticus*, sometimes called the *King's Books*, was compiled by his commissioners.

Taxation. In Political Economy, a tax is a contribution paid by the individual members of a community, with a view to supplying a fund out of which the general expenses of government, especially those which relate to the protection of person and property, may be duly liquidated. To the economist, the defence of taxation is to be found in the principle of the division of labour, and the advantages induced by such a division. Everyone would be prepared to admit that individuals, in the general interest of society, are not competent to interpret their own claims, to determine the extent of their own rights and wrongs, or, in justice or equity, to administer the law for their own sakes. But even were they able and willing to achieve such results, the economist argues that they could not do so as cheaply, as efficiently, and as continuously as a government, even when very imperfect, can do for them. It is true that sometimes an administration becomes so utterly depraved, or so rapacious, that society is disorganised, and men are obliged to take the protection of themselves into their own hands; or becomes so powerless, that its force has to be sustained or its negligence remedied by associations among private citizens. The first condition was exemplified towards the close of the Roman empire in the west; the latter in the organisation known under the name of the Vigilance Committee in the early history of the gold mining in California. Of course such expedients are desperate remedies, involving great waste of time and labour, a waste which those who feel constrained to adopt the measures thoroughly understand, and would gladly avoid by the payment of taxes, if it were only possible to secure the advantages of a just and vigorous administration. On the other hand, governments, however wise and well-intentioned, can seldom succeed in apportioning the burden of taxation on perfectly just and equitable grounds. It is the constant endeavour of good governments to effect such results, and in order to do so it

is necessary to lay down and generally follow certain definite rules.

History of Taxation.—In the early days of political civilisation, i. e. at the commencement of a system of responsible government, the machinery of the administration is simple, centring in one ruler, whose person is theoretically sacred, but who is liable to resistance, and in extreme cases to punishment for maladministration. Such a state of things characterised the feudal system, under which opposition to authority, insurrection, with the natural consequences to the losing side, the forfeiture of fiefs on the part of the vassal, and deposition or at least successful defiance when the monarch was defeated, were implied in the rights of defiance and private war. The occasions and process of these acts may be seen in Beaumanoir's *Customs of Beauvais*, ch. lix. lxvi. (Ducange, art. 'Diffidare.') To such theories we may trace the frequent revolts and insurrections which are to be found in our early feudal history. The doctrine that the king was irresponsible would never have been admitted down to the Restoration; and when the Revolution of 1688 formally established a constitutional monarchy, the theory that the king can do no wrong, originally an expression denoting his judicial equity, was transferred to his political status, and thereupon decorously evaded, by the rule that the king must be advised, but that his advisers are responsible for their counsel. In those days, then, all the proceeds of taxation were paid to the crown (cases in which a distinct appropriation of supply was made being treated rather as exceptions than precedents, such as some certain taxes paid in the reign of Richard II. and Henry IV.) and entered in the great Pipe Roll, along with other private and public sources of royal income. The efforts of parliament were therefore directed to the avoidance, not to the regulation of taxation, to stopping the supplies, not to their appropriation, and from the time of the Great Charter down to the Revolution, the limitation of the royal power was not unnaturally supposed to be connected with the scantiness of the royal revenue.

It appears (Hallam's *Constitutional History*) that the coldness which subsisted between William III. and his parliaments arose from the resolute determination on the part of the latter to make the crown dependent on the representatives of the nation. Thus they peremptorily resisted a favourite opinion of the king, that the large income which James had forfeited by his flight and by the action of the legislature was, eo ipso, vested in his successor. William knew very well that the resources of a monarch who exercised absolute authority over the means of war might be husbanded with far greater exactness, and employed with far greater effect, than those of which parliament superintended the expenditure. But the parliament had too bitter an experience of arbitrary government ever to let the privilege of control slip from their hands, even at the risk of some loss. We must remember, too, that the nation did not in William's reign enter into his large schemes of preserving the balance of power in Europe (a balance, by the way, of which he was the inventor); that it looked coldly on the policy which strove to check Louis XIV.; that it was by no means encouraged by the result of William's military measures, and did not heartily appreciate the prospect of acting as arbiter on continental questions, till after the splendid victories of Marlborough. But by this time the practice of appropriating the supplies had become a custom, and the parliament was the exponent of public policy.

The earliest English taxes were compositions for military service and levies on personal property. By the feudal rule, the military tenant was constrained to follow the bidding of his lord, and to take up arms at his discretion, whatever might be the distance of the expedition to be undertaken, and however unreasonable its object. In the reign of Henry II., whose dominions comprised nearly the whole seaboard of France, an arrangement was effected, by which the nobles were relieved from the obligation of taking their contingents to Toulouse, the price of the exemption, under the name of *escuage*, being fixed at twenty-five per cent. on the estimated rental of the knight's fee. The privilege of deciding the occasions on which this exceptional tax should be levied was accorded, by the terms of the Great Charter, to the parties who were to be made liable to the impost.

After the action of parliament, in the grant of taxes, was thoroughly understood, the chief source of extraordinary revenue was a property tax on chattels. This was granted by the House of Commons for the laity, by the Convocation for the clergy. The proportion varies greatly, from a sixth to a thirteenth, the larger nominal amount being granted by the clergy; but it was only nominally larger. It is clear that if the laity were taxed on all their movables, furniture, stock in trade, and even ready money in their possession, and the clergy on their tithes, that the tax was far more onerous in the former case, being on the capital of the former, on the income of the latter. This real inequality of taxation was a serious grievance, and provocative of great disaffection towards ecclesiastical privileges. The right of the clergy to tax themselves, an act which by some obscure process was necessarily confirmed by the House of Commons, was tacitly surrendered after the Restoration, in consequence, it is said, of a compromise entered into between Charles II. and Sheldon, archbishop of Canterbury.

Customs duties, as their name implies, are an ancient source of revenue. In the early history of England they were unimportant in amount, though sometimes export duties were onerous. It was believed that articles for which there might be a considerable foreign demand could be taxed without loss to the ex-

porter, and that the foreign consumer would really pay the charge. Nor were there any excise or internal duties. The origin of this latter class of taxes is to be found in the necessities of the two parties engaged in the contest between Charles I. and the Long Parliament. Excise duties were borrowed from the Dutch, who had been constrained during their long contest with the king of Spain to ransack every expedient with a view to discovering means for carrying on the war, and had consequently laid excise taxes on almost every article of internal consumption.

It was after the Restoration that the excise was formally and permanently established in England. The occasion of this great innovation was the necessity of devising some compensation to the crown for the loss of the feudal incidents affecting lands held by military tenure. Thus, for instance, the possessor of such an estate was liable to charges on descent and on alienation. In case he was succeeded by an infant heir, the rents and profits of lands during the heir's minority became the property of the crown, and were in the aggregate so considerable as to form the object for the investigations and procedure of a particular court called the Court of Wards and Liveries. These and similar imposts, though not productive of a very large income to the king, were vexatious and destructive to the lords, and, if they could not be totally abolished, needed reconstruction on a fair and intelligible basis. The most obvious compromise would have been a permanent tax in the shape of a fee-farm rent payable to the crown; and such a compromise was suggested in the reign of James I. But the first parliament of the Restoration achieved, by a majority of two (Nov. 16, 1660), and in spite of the energetic resistance of the members from the principal towns, the emancipation of their estates by the grant of the hereditary excise, i.e. they charged the whole nation of consumers with the liabilities to which they, the possessors of a certain portion of property, were subject. It is worthy of remark, that, while they freed their own estates at the expense of other people, they continued to retain, and still retain, their own rights as mesne lords over the estates of copyholders, who, being at that time unrepresented, had to submit in silence.

At the Revolution the proceeds of new customs and new excises were devoted to liquidating the interest, and, when the obligation was terminable, the principal, of new loans. If, as was often the case, the income from the tax was in excess of the annual sum demanded, the surplus was collected into a consolidated fund, and when fresh expenditure was needed the surplus income formed a basis for financial operations. Of course, in time, additions made to taxes ceased to be productive, partly because they were met by smuggling and frauds on the revenue, partly because consumption was checked by over-taxation. In short, as has been wisely observed, in the arithmetic of the custom-house two and two do not always make four. The practice of pretending to create a fresh income by an additional tax, and of affecting astonishment at the failure of such fiscal predictions, was carried to its height by Mr. Vansittart, whose absurd plans during his long tenure of office as chancellor of the exchequer had at least the merit of enabling more capable statesmen to realise the true theory of finance.

The duty of revising the customs and excise duties was urged, shortly after the peace, on the administration which held the reins of government for so long a period, and of which Lord Liverpool was the head. Timid at first, but still anxious to develope the resources of the country by removing the pressure of ill-advised taxation, successive cabinets have continued the work, until at present the revenue is derived from a very few articles; and the real questions left, on the understanding that the necessary charges of the state are to be procured in the least wasteful and onerous and most equitable manner, are chiefly those which bear on the respective merits of direct and indirect taxation, and those which attempt to settle the former on a fair basis.

The Principles of Taxation.—'The sting of taxation,' says Niebuhr, 'consists in wastefulness.' To this we may add inequality, unfairness, favouritism, and whatever else is included under the reproach of *class legislation*. The rules laid down by Adam Smith (*Wealth of Nations*, book v. ch. ii. part ii.) have become classical. 1. The subjects of every state ought to contribute towards the support of the government, as nearly as possible, in proportion to their respective abilities. 2. The tax which each individual is bound to pay ought to be certain, and not arbitrary. 3. Every tax ought to be levied at the time or in the manner in which it is most likely to be convenient for the contributor to pay it. 4. Every tax ought to be so contrived as both to take out and keep out of the pockets of the people as little as possible over and above what it brings into the public treasury of the state. In accordance with these rules, a financier should study *equity*, *certainty*, *convenience*, and *economy*, in the imposition of taxes.

Some difficulty has attached to the word *abilities* used by Adam Smith in his first canon of taxation. But it seems manifest that the author of the *Wealth of Nations* has explained his use by the illustration which he appends. 'The members of a community,' he says, 'are like the joint tenants of a great estate, whose contributions are relative to their respective interests in the estate. From this point of view, as the interests must be estimated according to the value of each share, equity in taxation according to abilities must be proportioned to the capital value of each man's property in the state, whether that capital be represented in objects external to him, or invested, so to speak, in himself; whether, in short, it be property or skilled labour.' It will

be observed that Smith does not recognise the principle which has been occasionally advocated, that, namely, which holds the liability to taxation to be relative to the protection accorded by the state—a rule which, if admitted, would consistently levy the heaviest taxes on women, children, and others who are least capable of protecting themselves.

Granted, however, that taxation is fairly apportioned, or at least as fairly as can be effected by the ingenuity of financiers, the main rule is that which provides that as little loss as possible shall be involved in the collection of the tax. To effect this result, the least possible time should be interposed between the levy of the tax on the article consumed (if the tax is a duty on goods) or used (if it be an article representing fixed capital). Again, if the collection of the tax involves a number of minute details, the cost of collection may become disproportionally large; or if the producer of the article upon which the tax is levied is subjected to vexatious supervision, the manufacture may be abandoned altogether, or the price of the article may be unduly enhanced.

It is easy to illustrate irregular and wasteful taxation from the records of financial history. Nothing could have been more unwise than the policy of the government of this country till within the last twenty years. For instance, up to within a comparatively short period, a customs duty was levied on raw cotton, an excise on printed calicoes. No tax can be worse than that which is levied on a raw material, because, as a portion of the capital of the manufacturer is absorbed in paying the tax, and as this portion must secure a profit, and be insured against risk, not less than that which is employed in the purchase of the raw material and the advance made for the wages of labour, and as this tax is levied at or before the commencement of the process, it will ramify through all the stages of the manufacture, and appear as an accumulated impost to the consumer, the amount thus paid being far in excess of that received by the exchequer. Furthermore, it is grossly unfair, being much more heavy on cheaper than on dearer stuffs. Nor can it easily be compensated when the same article may be imported from foreign countries, in which no such tax exists, except by a duty which is almost prohibitive. And as raw materials are generally imported from countries which take manufactured goods in exchange, such a tax, as it diminishes consumption by an import unduly enhanced, seriously impairs or contracts foreign trade. The same objection applies to taxes on food, which are in effect taxes on the raw material of human life. These taxes have this evil in addition, that they contribute to the exchequer only from that which is imported, while they mulct the public in all which is consumed.

The excise on printed cottons was mischievous on other grounds. Of course it checked consumption. But it did so in consequence not only of the enhanced cost which the tax involved, but of those hindrances to improvement which excise regulations, being of the character of a detective police, invariably create. The principal part of the direct loss involved in the excise lay in the fact that the duty paid on the conclusion of the manufacture was affecting the price up to the time in which the goods were sold, and, in case the goods were long in sale, formed a notable part in the risk of the undertaking. Nothing, in effect, could have been more striking than the consequence of repealing the excise duty. In a short time, notwithstanding the enormous profits of the manufacturers and the printers of cloth, the price of printed calicoes, by the mere force of competition and improvement in the process of manufacture, actually fell below the amount which had previously been paid for the excise. It is hardly necessary to say that this cheapness operated indirectly in a multitude of ways to the benefit of the revenue, by increasing the powers of consuming, duty-paying, and excisable commodities on the part of both manufacturers and factory hands.

Another instance of the effects of an excise on a raw material (not, however, suffered except indirectly, and in the form of insurance against risk, by the consumer, but chiefly by the producer) was found in the excise on hops. The cultivation of hops was essentially a gambling transaction. The demand for hops is, on the whole, even, year after year. The quality of the article is best when it is just prepared, and it rapidly deteriorates by keeping. Hence the effect of the excise duty was mischievous in the last degree. If the crop were abundant, the cultivator was ruined, or at least seriously mulcted, by the magnitude of the tax, and the fall in the value of the produce. If, on the other hand, the crop was scanty, the value of it fell below the cost of production. The hope of the hop farmer lay in an average crop. It was an indirect feature in the incidence of the excise that it stimulated the habit of gambling. Nothing was more common than the practice of staking great sums in bets on the amount of the hop duty.

At present all taxes on raw materials are abolished: the last, and one of the most objectionable—that on timber—having been repealed in the budget of the present year (1866).

The Incidence of Taxation.—It does not follow that a tax is really paid by the person from whom it is actually received. He may be the mere channel through whom the payment is made. Many a person thinks he pays taxes, and acts on the supposition, when he is a mere agent for others. This fact may be readily illustrated. A tax, for example, on rents is paid by the landowner. There is no means by which he can shift the tax from himself to others. Similarly, if any tax is paid, no matter by what person, which reduces the power or the inclination of such a person to pay rent, the tax is really paid by the landowner, since, as we have seen above [RENT], rent is what remains after the capitalist and labourer are recom-

pensed from the produce. Thus, a tithe-rent charge is paid not by the farmer, but by the land-owner. It is manifest that, were the tithe abolished, rents would rise, and the rent charge would be transferred from the parson to the landowner, as is virtually the case when lands are tithe-free. But, on the other hand, a poor-rate, in so far as the landowner is directly or indirectly an employer of labour, does not fall on the landowner at all. It is in such a case, even were he to pay all the poor-rate, merely a displacement of a part of wages—an insurance fund paid from wages, for if the aid of the poor-rate were not granted to the labourer, wages would inevitably rise by at least the whole amount of the rate, and probably to a greater extent; and in so far as the poor-rate is paid by those who are not employers of labour, the tax is a direct relief to the landowner or the employer of labour, who gets labour at lower rates, because a portion of the poor-rate, which is, economically speaking, the *fund devoted to the insurance of labour*, is paid by other persons.

Again, an income-tax paid from fixed sources, as the rent of land, the profits of stock, and, generally speaking, from the revenues of those who cannot raise or depress the amount of their income, is paid by those who contribute it. But it does not follow that an income-tax derived from the profits of business is paid by the trader. He may, and probably does, compensate himself for the increased cost at which he is compelled to carry on his business by increased rates on the goods in which he deals, and this even when his business is exposed to competition. In such a case, the payment made by the recipient of a fixed income may contain not only his tax, but the tax of others, indirectly laid on him. Nor is it possible to evade this displacement by the machinery of any income-tax, though it may be by a property-tax, for the utmost which such an impost could effect would be a discouragement to accumulation. But this discouragement is a very remote hypothesis.

So a license on trade or practice, though seemingly paid by the licensed person, is really paid by the public. The tendency of profits and wages, cæteris paribus, is towards an equality. No man, however, will voluntarily put himself under a disadvantage, and if he can shift it where it is imposed, he will do so. A license, then, is similar in character to a tax on raw material: it multiplies itself, and causes far more loss than it reaps of profit. Sometimes, indeed, it may affect more parties than one. Thus, the tax on male servants is confessedly a check on the employment of such persons. It probably affects employers, and it certainly is a hindrance to some kinds of labour. The tax, on principle, is wholly indefensible. Again, an excise duty on malt, if indeed it affects agriculture unfavourably and prevents the cultivation of barley, is a tax on rents as well as on consumers. If it does not, it is a tax on the consumers of beer only. Nothing but the most inveterate stupidity could interpret the malt-tax as a tax on farmers. It may be a mischievous form of taxation, but it cannot be any special grievance to tenant farmers. It is perfectly certain that many worse taxes exist, the repeal of which is far more urgent.

One of the most notable among unfair taxes, some time ago repealed, was the tax on goods sold by auction. If all sales were visited with a pro ratâ tax, the measure, though a gigantic act of folly and waste, would be fair. But a tax on auctions is in the last degree unjust. In the first place, it was exceptional, and in the next, it was levied on sales which, in nine cases out of ten, represent poverty and distress. When the tax was repealed, the opposition to its erasure from the statute book was very strong, on the common but very foolish plea that a repeal of taxation cannot be attempted in the face of a deficit or an apprehended deficit. Similar in principle, and almost as indefensible, are the enormous taxes levied on mortgages. They would be less unfair if equal or analogous imposts were laid on all loans, or contracts for capital.

Much needless labour has been expended on deciding whether particular taxes are levied on profits or capital. Thus, on the hypothesis that taxes on capital are inexpedient, Ricardo argued that legacy duties were mischievous. In the opinion, however, that a legacy duty is a bad tax, this author stands almost alone. If there be any case in which an impost can be fairly laid, it seems to be in the instance of transmitting property on which the recipient has devoted neither labour nor capital of his own; and the graduated tax on the devise of personal property, though not quite just, is, perhaps, sound in principle and fairly equitable in practice.

In point of fact, the question whether property is capital or income is settled by the individual. As a rule, it is no doubt the former, but it lies with the discretion of the recipient whether it should not be the latter. If a man spends a legacy, he makes it part of his income; if he invest it, it is part of his capital, and if he be resolved to invest it, it is not easy to see, after the first charge which a government may put upon it, how such capital may, if financial expedients be even ordinarily equitable, be subject to taxation at all. It is possible that capital may be taxed; it is taxed by the practice of the income-tax, but this tax cannot be defended on any rational plea, since the charge on the profits of fixed or destructible capital is levied at the same rate as that on floating or permanent capital.

All taxation is, no doubt, an evil. But it is to the person who pays the tax, not necessarily to the community. It curtails the power of enjoyment possessed by individuals, and as individuals may fairly be acknowledged to have

the right of enjoying the fruit of their labours, any diminution of their enjoyments can be justified only on the ground of their ultimate advantage, or the common good of society. If any man pays a tax, he has so much less to spend for his own purposes; but he should, and in all well-administered governments he does, understand that the diminution of resources to which he must submit gives him larger and more convenient powers over the remainder.

But it does not follow that the loss to the individual may be a loss to the community. For instance, suppose a government levies a tax the effect of which on A is to deprive him of the power of buying a picture, and on B of obliging him to buy one picture a year less, and, with the proceeds of the tax, hires soldiers. The demand for pictures may be diminished, and, pro tanto, the labour of the painter may be discouraged. But general labour is benefited, partly in the diminution of labourers consequent on the demand for soldiers, partly by the competition for the supply of maintenance to such soldiers. And if the proceeds of the tax are devoted to really productive objects, as building a bridge, digging a canal, forming a road, laying out a railway, and the like, the general community may be greatly benefited by such a tax, and, after all, the person who pays it may not be absolutely mulcted.

Capacity for Taxation.—Taxation does not necessarily form a hindrance to the energies of a nation. Nothing could have been more onerous than the taxes laid on the Dutch during their war of independence. But Holland, even under this pressure, became in spite of great disadvantages the wealthiest community in Europe, contesting, and for a long time with great success, the empire of the seas; and it lost its mercantile and political supremacy, not from the pressure of its financial difficulties, but through its obstinate adherence to a mistaken commercial policy. After the peace of 1815, when the tariff of this country was constructed on principles which utterly defied all common sense, the elasticity of trade, and the energies of the people, favoured to some extent by the fact that other governments were even more unwise than our own, enabled the nation to make astonishing progress. What that progress might have been, had it never been hindered by the policy of Mr. Vansittart and Lord Castlereagh, may be conjectured from the progress made since that policy has been abandoned.

The capacity for paying taxes is, on the whole, measured by the margin over and above their necessary expenditure which remains to the mass of the community. Unless all taxes are raised directly from income and profit, a state of things which has never been realised in practice, and only faintly suggested in theory, indirect taxes, in order to be collected at a moderate charge, must be levied on articles of general consumption, i.e. on such secondary necessaries of life, or ordinary luxuries, as are enjoyed by the mass of the people. This, it is notorious, is the case with the financial system of this country, the revenue of which, as derived from customs and excise, amounted to nearly forty-one millions in the last financial year. Of this sum, by far the largest amount was derived from the contributions of those who are inaccurately called the *working classes*, but who would be more exactly described as persons possessing less than 100*l.* a year of annual income.

In the United States, the margin available for taxation is far larger, as the rate of profit and the rate of wages are higher, and the rent of land is low. Hence financial difficulties which might stagger other communities would be easily borne by that republic. We know, in our own country, that, owing to reforms in our commercial policy, taxation which used to be intolerable has become comparatively easy, while in the United States the all but unlimited resources of the soil and the energy of the inhabitants are sufficient to countervail that mischievous adherence to a protective system, which cripples the energies and discredits the intelligence of the American people. Countries, in short, in which the mass of the people is impoverished, however gorgeous and imposing may be the wealth possessed by a few, are poor, weak, and unable to meet the exigencies of a large public expenditure; while, on the other hand, those communities in which wealth is abundantly distributed, and in which comfort and comparative affluence are shared by most members of the society, are capable (not only for political, but for economical reasons) of supplying, with but little privation, abundant means for the necessities of government.

Protective Taxation.—We have already [PROTECTION] commented on the arguments alleged in favour of protection, and the refutation which has been conclusively directed against these arguments. At the present time, the policy of our government has professedly been to treat all taxation as a question of revenue, and to ignore any effects which it may have on stimulating or supporting domestic industry. It is intended that every article of home or foreign production or manufacture should be put on the same level, and that no favour of any kind should be shown. As a rule, the principle is sustained, though there is still one notable exception. If the object favoured by a protective arrangement is a manufacture, the consumer invariably pays more for a worse article; if it be a necessary of life, he pays the duty on all that is consumed of it, the state obtaining a revenue only on that which is imported. Thus, although at the repeal of the corn laws only a shilling duty was retained on grain, yet as, even when the harvest is most abundant, considerable quantities of foreign corn are always imported, the whole amount of grain sold is raised by the shilling tax, this tax being on an average about 2½ per cent. on the value. This 2½ per cent. is a bonus to the landowner, and is appropriated by him naturally in the shape of rent. The amount of indirect aid thus accorded to landowners has been reckoned on an

average at 4,000,000*l.* per annum, the amount raised as revenue being under 400,000*l.*

Import and Export Duties.—It has been already stated that a considerable part of the revenue of this country is raised by customs on six principal articles, tea, coffee, tobacco, sugar, corn, and alcoholic fluids. Of these, the largest amount is derived from sugar and tobacco, which together contribute more than half the customs duties. These taxes may be said to be paid for the most part by the poorer classes, who are the great consumers, by virtue of their numbers, of the commonest luxuries and the most familiar among the secondary necessaries of life. The tax on tobacco, though enormous, does not seem to provoke much smuggling; and on the hypothesis that all members of the community ought to contribute to the exigencies of the state, no two taxes, it seems, could have a fairer incidence on consumption than these.

No community whose system of finance is managed with the commonest reflection imposes an export duty on its productions. It sometimes appears, however, to the administration of particular communities, that there are commodities in which it possesses peculiar advantages. Such, for instance, was wool to our forefathers, such is sulphur to Sicily, such was cotton to the Southern States of the American Union. Now, under such circumstances, it is common for governments to imagine that an export duty will be paid by the consumer. But the impression is a delusion, and the action consequent upon this impression is sure, at no remote period, to destroy the peculiar advantage possessed by the community in question. If, indeed, the article were an absolute necessary of life, if it were obtained in one region only, and the administration of such a region could completely control the supply, it would be possible to levy a general tribute on the whole world by the imposition of an export duty. But there is not, and, as a little reflection will show, there cannot be, any such commodity; while, if there should be an accidental advantage, the attempt to control the market is sure to be met, and successfully obviated, either by obtaining a supply from other regions or by the substitution of some other article. The English government prohibited the importation of colonial sugar into France during the continental war. At that time this country had a complete control over the supply of this tropical produce. The result was the establishment of a manufacture of sugar from beet. It adopted the same policy with saltpetre, then derived entirely from India. A successful home manufacture was rapidly developed. The Sicilian government attempted to control the export of sulphur, an absolute necessary for the manufacture of sulphuric acid. The material was obtained from pyrites. Instances might be multiplied to prove how futile is every attempt (whether it be for fiscal or for military purposes) to control the consumption of foreign countries, or to levy an indirect tax on them, by any regulations intended to prohibit exports or to render them a source of revenue.

Local Taxation.—Accounts given of the annual revenue of foreign countries generally include a portion of income which is omitted in the statement of our own expenditure, and omit an item which is formally contained in that of Great Britain. Both the omission and the inclusion are due to the fact that in this country there is a perpetual tendency 'to decentralise,' a term by which continental nations express the attempt to leave as wide a range as possible to the free action of individuals, to municipal or local activity, to what, in short, we call self-government. Thus the various local taxes, such as the poor-rate, the highway, county, and police rates, the charges for municipal management, lighting and paving, &c., are not included in the general budget, because they are locally imposed and locally administered, whereas in most foreign countries they are under the control and distribution of a central bureau. On the other hand, part of the charges which belong to the department of the army in this country, the cost, namely, of recruiting, is met in other countries by the system of conscription, or militia.

It is by no means easy to give any exact account of local taxation. The aggregate of poor and county rates in England is nearly ten millions annually, the former of these two items varying but little, the latter rapidly and steadily increasing. In Ireland and Scotland, the sums expended on the relief of the poor are nearly the same, about three-quarters of a million in each kingdom. But there are many other local charges evidence of which is deficient. Perhaps the amount would not be over-estimated at fifteen millions.

By far the greater part of this taxation is immediately returned to those who pay it, or at least to some of those who contribute to the fund. We have shown above [PAUPERISM] that a poor-rate is an indirect way of paying wages, and that, in the absence of such a rate, wages would inevitably rise. So, again, a road-rate is only a means by which every person who makes use of a road is called on to contribute towards its maintenance; a contribution which is unfairly and wastefully levied when it takes the shape of a toll, collected at a gate: unfairly, because many persons use the road, and use it very roughly, who do not pay the toll; wastefully, because the receipt of the toll is burdened with a great charge in collection. It would be both just and expedient if all tolls taken for public services were commuted into general rates, and apportioned according to assessment or property possessed or occupied within the region which gets the benefit of the service.

Direct and Indirect Taxation.—By far the largest portion of the public revenue in this country is obtained from indirect taxes, i.e. from taxes levied on commodities to be consumed, and not on income or the power of consumption. By the machinery of bonded warehouses, the

incidence of indirect taxation is made as light as possible, and, by a judicious tariff, the temptations to smuggling and similar illicit practices are greatly diminished. Public opinion, in short, has powerfully supported government in checking frauds on the revenue, because it has been felt that, in the assessment of customs duties, the ends of the government have been intelligible, and its administration honest. High duties, no doubt, stimulate smuggling: but oppressive, capricious, or interested taxation does so in a far greater degree. Nor can it be said that the system of indirect taxation checks commercial enterprise, or hinders England, in the language of those who favour direct taxation, from becoming the free port of the world.

Of late years attention has been constantly called to the merits of these rival methods. It is urged that direct taxation could be levied with greater economy, and that, its incidence being felt more keenly than that of indirect taxation can be, there would be a more watchful supervision over public expenditure. It is also said that direct taxation is fairer than indirect. But it is hardly conceivable that an absolutely direct system of taxation (embracing, in order to be equitable, all incomes, however small) could be carried out at all, or, if carried out, could be effected at small expense, unless every man who paid wages, or bought commodities, were constrained to be a tax-gatherer. Nor, to judge from present experience, does it seem likely that this keen insight into public expenditure would ensue from direct taxation. Almost all local taxation, amounting on the estimate given above to little less than a fourth of the imperial taxation, or, setting aside the interest of the debt and the immediate charges of government, to nearly half the imperial taxation, is obtained directly; and yet perhaps no portion of the moneys which individuals pay for public purposes is under less control, supervision, and criticism, than is this local taxation.

Nor, if we are to argue from the principle on which the income-tax is assessed, and assume that this principle should form the basis of all taxation, would much be done by way of equity. There are very few persons who are not convinced that the income-tax is other than unfair and unequal, although as yet the true principle of such a tax has not been allowed, nor, were it proved, is it likely that it would be accepted. In short, the arguments alleged by those who are called financial reformers, and who declare that all indirect taxation should be abandoned in favour of a direct system, are, we may admit, theoretically sound, but demand a higher moral tone, and perhaps a larger amount of economical reasoning, than the present state of society possesses, or is capable of comprehending. It is certain that, among existing direct taxes (to omit the income-tax, the strongest example of unfairness), those which are levied on successions, with the irrational distinction between real and personal property, on conveyances, and on insurance, where an equally irrational distinction is made between farming stock and other property, are the worst and most flagrant examples of one-sided legislation.

Taxicornes (Lat. taxus, *a yew-tree*; cornu, *a horn*). The name of a family of Coleopterous insects, including those in which the antennæ gradually increase in size as they extend from the head, or terminate in an enlargement.

Taxidermy (Gr. τάξις, *arrangement*, and δέρμα, *skin*). The art of arranging and preserving the skins of animals. The most popular treatise on taxidermy is Mr. Swainson's volume in *Lardner's Cyclopædia*.

Taxis (Gr.). In Surgery, the replacement of parts, which have quitted their natural situation, by the hand, and without instrument or operation; as in reducing hernia or rupture.

Taxodium. A genus of *Coniferæ*, of the tribe *Cupressineæ*, consisting of lofty trees, inhabiting for the most part the rich swampy soil of Florida and other Southern States of North America. The Deciduous or Bald Cypress, *T. distichum*, is an ornamental tree commonly seen on lawns and in similar situations, where its feathery foliage renders it an attractive object. In its native country its bark and wood are much used for covering houses, for thin planks, ribs of ships, water-conduits, and other purposes. The roots sometimes bear large hollow excrescences, which are made use of by the negroes as beehives.

Taxus (Lat. *the Yew-tree*). The Common Yew, *T. baccata*, is a well-known evergreen tree, characterised by a trunk peculiarly suggestive of massiveness and solidity, not being covered, like the trunks of most other trees, with a splitting bark, but seemingly composed of a number of smooth stems fused together, and sending out numerous horizontal branches, which spread in all directions, and are densely clothed with tough twigs, on which the numerous leaves are thickly set on opposite sides. The flowers are of two kinds, and grow on separate trees. The fertile flower resembles a minute acorn, the cup of which swells, and, when ripe, has the appearance of red cornelian, enclosing a small oval brown nut, the summit of which is uncovered. These fruits drop when ripe, and contain a sweet glutinous juice of a mawkish disagreeable taste, but are eaten with impunity by children, and are greedily devoured by wasps, moths, and several kinds of birds. The leaves are poisonous, though to what extent is a disputed question; but there can be no doubt that their effects on the human frame are deadly, and that to allow cattle to eat them is a perilous experiment. The poison appears to be more virulent in the young shoots than in any other part of the tree, but exists, in greater or less quantities, both in the fully-expanded leaves and in the green bark. The leaves are more dangerous in a half-dry state than when fresh. 'Yew-tree tea,' an infusion of the leaves, is, according to Dr. Taylor, sometimes used by the poor and ignorant for

the same purposes as savin, but with equal danger. The wood is hard, compact, of a fine and close grain, elastic, and incorruptible, of a fine orange-red or deep-brown; the sapwood being white and also very hard. The fineness of its grain is owing to the thinness of its annual layers, the Yew-tree being of exceedingly slow growth; 280 of these layers are sometimes found in a piece not more than twenty inches in diameter.

The Yew is a native of most of the temperate parts of Europe and Asia, and is generally found growing in a clayey, loamy, or calcareous soil, which is naturally moist. Yew-trees of great antiquity and large size are often to be met with in old churchyards, but from what motive they were planted in such situations is not clearly ascertained. Some of the various reasons assigned are, that the poisonous foliage of the yew typified death; that its durability and slowly-altering features symbolised the Resurrection; that it might afford a supply of twigs to be worn on Palm Sunday;—from a still more utilitarian point of view, that there might be always at hand a supply of wood for making bows. Yews are in existence which are supposed to be above a thousand years old. The dimensions of the largest range from thirty to upwards of fifty feet in circumference.

Taylor's Theorem. This important theorem was first given by Brook Taylor in his *Methodus Incrementorum*, Londini 1715; it furnishes, whenever possible, the developement of a function $F(x+h)$ in ascending powers of h. Lagrange, as is well known, proposed to found the whole differential calculus upon Taylor's series; its want of generality, however, has been justly urged as an objection to such a proposition. Besides Taylor's own proof of his theorem, others have been given by Maclaurin and Stirling, D'Alembert and Cauchy, Lagrange, Ampère, and others. In all treatises on the calculus, one or more of these proofs will be found; we shall, therefore, simply give the theorem, and refer the reader to such sources for further details. Denoting by $F^{(i)}(x)$ the i^{th} derived function of $F(x)$, we have—

$$F(x+h) = F(x) + \frac{h}{1}F'(x) + \frac{h^2}{1.2}F''(x) + \ldots + \frac{h^i}{1.2\ldots i}F^{(i)}(x) + R_1,$$

which is true when neither $F(x)$ nor any of its derived functions become infinite for values of x between which the theorem is employed. The *limit*, *residue*, or *remainder* R_1, which it is always necessary to add in order to render the formula exact, may be expressed thus—

$$R = \frac{h^{i+1}}{1.2\ldots(i+1)}F^{(i+1)}(x+\theta h).$$

Cauchy's equivalent form is—

$$R_1 = \frac{(1-\theta_1)^i h^{i+1}}{1.2\ldots i}F^{(i+1)}(x+\theta_1 h),$$

and in both θ and θ_1 are *proper* fractions. Employing a definite integral, this residue may be thus exhibited—

$$R_1 = \frac{1}{1.2\ldots i}\int_0^h z^i F^{(i+1)}(x+h-z)dz.$$

When $F(x)$ is a rational and integral function of the n^{th} degree, R_1 will be 0, and the series will end with the $(n+1)^{th}$ term. If it can be proved that R_1 vanishes when i is increased without limit, then $F(x+h)$ may be expressed by the corresponding infinite series, provided the same be convergent. It is necessary to bear in mind, however, that the converse is not necessarily true; the infinite series may be convergent, and still not represent the value of $F(x+h)$, since R_1 may not vanish; hence the necessity of taking the residue R^i into consideration. In such cases Taylor's theorem is said to *fail*.

Taylor's theorem may easily be extended to functions of two or more variables; the result, however, is most conveniently expressed in the symbolical form. To illustrate this, let the symbols of operation and quantity in Taylor's theorem be separated. We may then write it thus—

$$F(x+h) = \left(1 + h\frac{d}{dx} + \frac{h^2}{1.2}\frac{d^2}{dx^2} + \&c.\right)F(x)$$
$$= e^{h\frac{d}{dx}}F(x).$$

The expression $e^{h\frac{d}{dx}}$ is purely symbolical, and acquires a meaning only when developed as if $h\frac{d}{dx}$ were a symbol of quantity. Similarly, in the case of two independent variables, the operative symbols $\frac{d}{dx}, \frac{d}{dy}$ being commutative, and combining with each other, and with constants, in precisely the same manner as if they were symbols of quantity, the symbolical equation $e^{h\frac{d}{dx}}e^{k\frac{d}{dy}} = e^{h\frac{d}{dx}+k\frac{d}{dy}}$ may be easily verified.

And thence we may deduce the expansion—

$$F(x+h, y+k) = e^{h\frac{h}{dx}}e^{k\frac{d}{dy}}F(x,y)$$
$$= e^{h\frac{d}{dx}+k\frac{d}{dy}}F(x,y)$$
$$= \left[1 + \left(h\frac{d}{dx} + k\frac{d}{dy}\right) + \frac{1}{1.2}\left(\frac{d}{dx} + k\frac{d}{dy}\right)^2 + \frac{1}{1.2.3}\left(h\frac{d}{dx} + k\frac{d}{dy}\right)^3 + \&c.\right]F(x,y).$$

The extension to functions of any number of variables is now manifest.

Tchingtchang. The Chinese name for dark-blue Lapis Lazuli containing spangles of Iron Pyrites.

Tchornozem. The name locally given to a singular but very important black earth covering at least a hundred million of acres of country extending from the eastern foot of the Carpathians to the Ural Mountains,

and having a thickness sometimes amounting to twenty feet. It is at various elevations, but its composition is the same everywhere. It contains 75 per cent. of silica, 9 per cent. of alumina, about 7 per cent. of decaying organic matter, with an unusual proportion of nitrogen gas and very little lime. More than 5 per cent. of oxide of iron is often present. Among the many rich soils in various parts of the world, none are more remarkable than this for the number of similar crops that can be obtained in succession without the smallest preparation or precaution. The nitrogen and organic matter contained in it are, no doubt, the great causes of this fertility, but the mechanical state of the soil is an important adjunct.

Te Deum (from the first words of the original Latin, 'Te Deum laudamus,' *We praise Thee, O God*). The authorship of this hymn has been ascribed by some to Ambrose and Augustine; by others to Ambrose alone, to Hilary, and to other less distinguished persons. It is, however, generally thought to have been composed in the Gallican church: the most ancient mention of it being in the rule of Cæsarius, bishop of Arles in the fifth century. The Te Deum, in the office of matins, is always sung after the reading of Scripture; in the English morning service, between the two lessons. (Palmer, *Origines Liturgicæ*, ch. i. part i. sec. ii.)

Tea (Chinese tcha or tha). The popular name of the plants belonging to the genus Thea, which yield the tea of commerce.

Various plants, possessing, in some part of their structure, peculiar stimulating and sedative properties, and acting, in medical language, also as emulgents, have long been employed, when infused, as a beverage. Chemical analysis detects the same or a similar principle in the leaves of the tea-plant, in the berries of the coffee, in the bark of the *Ilex paraguayensis*, and in the Peruvian coca. Of these, the best known to us are tea and coffee, the former having been used time out of mind by the Chinese.

The Chinese names given to the different teas are usually derived from their appearance or place of culture. Thus Souchong, or Sian Chung, means *little plant*; Hyson, from Yu Tsien, *before the rains*, or Hichun, *flourishing spring*, from the fact of the leaves being gathered early; Pekoe is from Pecco, *white hairs*, because the very young leaves from which this tea is made have a white down upon them; Bohea is derived from the Bw-i Hills, where this tea is produced. (*Quarterly Review* 1864, part ii. p. 22.)

The name Tea is also applied to the dried leaves of various plants, and to the infusions prepared from them, and used either as beverages or medicinally. Of these the chief are: Abyssinian or Arabian tea, prepared from *Catha edulis*; Australian or New Zealand tea, obtained from several species of *Leptospermum* and *Melaleuca*; Faham or Bourbon tea, obtained from *Angræcum fragrans*, an infusion of which is drunk to promote digestion, and the odour of which is owing to the presence of coumarin: Labrador tea, obtained from *Ledum latifolium*; New Jersey tea, the produce of *Ceanothus americanus*; Paraguay tea, obtained from *Ilex paraguayensis*; South-Sea tea, obtained from *Ilex vomitoria*; and Theezan tea, obtained from *Sagaretia theezans*.

Tea was not known in England till the close of the seventeenth century. But its use was fully established by the middle of the eighteenth century. Tea is enumerated among excisable articles in the year 1660, the form of the duty being 8*d*. a gallon on the infusion supplied in coffee-houses, commuted to an excise of 5*s*. the lb. in 1689. In 1667, the East India Company directed their agent at Bantam to purchase 100 lbs. of the best tea that he could find. In 1711, the quantity consumed in England was nearly 150,000 lbs., the retail price being very high: domestic account-books, still preserved, often recording purchases at from 17*s*. 6*d*. to 20*s*. the pound. In the time of Arthur Young, about 1770, the consumption had increased to 7,000,000 lbs., and this writer laments, throughout the records of his agricultural tours, that the peasantry had abandoned the use of the national beverages and taken up with tea.

The chief consumers of tea are the English, the Dutch, the Americans of the United States, and the Russians, the importation in the first three cases being effected by a sea passage, in the last by caravans. It is said that tea carried on sea always loses a portion of its flavour, and that the finest qualities are found in Russia. Tea reaches us in chests, and in the well-known form of dried and rolled leaves. Much, however, of that which is imported to Russia is pressed into cubical masses, and is known as brick tea. This is the form in which it is most frequently found in Central Asia. (See the travels of Huc and Gabet, Atkinson, and Vambéry.)

The chief source of tea is China, where it is cultivated over a vast district between the twenty-fifth and twenty-third degrees of latitude. It is also grown in great quantities in Japan, in latitudes at least ten degrees north of the China districts; and teas of excellent quality are coming into the market from these islands. It is an increasing object of agriculture in the Eastern Himalayas, particularly in Assam, the produce of which bears a higher average price than that of any other locality. There is nothing, except the cost of labour, to interfere with the production of tea over the whole coast of the Mediterranean, for the tea-plant is a hardy evergreen, which can withstand the cold up to at least the fortieth degree of latitude.

Teas of the finest quality are, like wines, the growth of particular districts, and even of particular estates, the best kinds being prepared with extraordinary care, and selected with great exactness. The gardens and small

plantations in which the tea is grown and prepared are visited by regular purchasers, who collect the produce in order to forward that which is intended for the foreign market to the various ports frequented by Europeans. The finest packages are marked with a particular stamp, called a *chops*, a Chinese word said to signify a seal. The agents, through whose hands alone foreigners could make their purchases, were formerly known as the merchants of the Hong, and it is stated that the commercial credit of these merchants was held in the highest estimation.

Up to the year 1834 the trade in tea was the monopoly of the East India Company. This monopoly was, as our readers are doubtless aware, the proximate cause of that outbreak at Boston in the year 1770 which led to the independence of the United States. The privilege was exceedingly oppressive to the English public, and of little or no value to the company. It was stated in 1830, only four years before the abolition of the company's monopoly, that the cost of protecting the tea trade had been so great as to leave absolutely no profit. It was estimated, however, that the annual loss of the public in consequence of the company's monopoly was not less than 600,000*l.* or 700,000*l.* per annum. The abolition of the privilege was therefore passed in 1833 almost by acclamation.

The duties on tea were originally ad valorem, and calculated on the company's sales. After the abolition of the company's monopoly, the duties were paid at rates varying from 1*s.* 6*d.* to 3*s.* But the discriminating duties worked ill, as, indeed, such duties always do, and in 1836, an equal duty of 2*s.* 1*d.*, increased in 1840 to 2*s.* 2½*d.*, was substituted. In 1854, a set of new duties was fixed, on a gradually reducing scale, to commence, in 1854, at 1*s.* 10*d.*, to go on from April 1854 to April 1855 at 1*s.* 6*d.*, from April 1855 to April 1856 at 1*s.* 3*d.*, and to become 1*s.* at the latter date. The Crimean war disturbed this arrangement; the duty was raised to 1*s.* 9*d.*, and was reduced in April 1857 to 1*s.* 5*d.* In 1863 the duty was reduced to 1*s.*, in 1865 to 6*d.*

The two kinds of tea, black and green, do not differ generically, being merely varieties of the same plant. The plants are picked four times in the year, the finest kinds being the leaf-buds collected in the spring, called *pekoe*; the poorest that gathered in the autumn, and known as *bohea*. Green teas are occasionally faced with indigo, Prussian blue, and other drugs; but it does not appear that adulteration is carried on largely in China. It is said that frauds are practised in this country, by mixing sloe and ash leaves with tea, or by unrolling and dyeing tea-leaves which have already been infused. An Act of 4 George II. (so early were these dishonest practices commenced) prescribes a series of penalties for these offences.

The following tables give: (1) the imports of tea for the last ten years; (2) its value; (3) the price per pound of the principal kinds of tea in bond at London, for nine years:—

Years	Lbs.	£
1856	86,100,404	5,248,834
1857	64,493,987	4,677,470
1858	75,432,535	5,206,618
1859	75,077,451	5,812,545
1860	88,946,532	6,911,943
1861	96,577,888	6,850,562
1862	114,787,361	9,175,940
1863	136,806,321	10,666,017
1864	124,359,243	9,438,760
1865	121,271,219	10,044,462

Years	China	Assam	Japan
	Per Lb. *s.* *d.*	Per Lb. *s.* *d.*	Per Lb. *s.* *d.*
1856	1 2⅛	2 4¾	—
1857	1 5⅛	2 1¼	—
1858	1 4½	2 0	—
1859	1 6½	2 0	1 6
1860	1 9⅝	1 9	1 6
1861	1 5	1 9⅛	1 5
1862	1 8 3/16	1 9	1 7
1863	1 6⅝	1 11⅞	1 5⅝
1864	1 6	2 3	1 3¾

For further particulars, see *Commercial Dictionary*, art. 'Tea.'

Teak or Indian Oak. The produce of the *Tectona grandis*, a large forest tree, which grows in dry and elevated districts in the south of India, the Burman Empire, Pegu, Ava, Siam, Java, &c. Teak timber is one of the best in the East; it works easily, and, though porous, is strong and durable; it is easily seasoned, and shrinks very little; it is of an oily nature, and therefore does not injure iron. Mr. Crawfurd says that, in comparing teak and oak together, the useful qualities of the former will be found to preponderate. 'It is equally strong, and somewhat more buoyant. Its durability is more uniform and decided; and to insure that durability, it demands less care and preparation; for it may be put in use almost green from the forest, without danger of dry or wet rot. It is fit to endure all climates and alternations of climate.' (Tredgold's *Principles of Carpentry*, p. 206; Crawfurd's *East. Archip.* vol. i. 451.)

The teak of Malabar, produced on the high table-land of the south of India, is deemed the best of any. It is the closest in its fibre, and contains the largest quantity of oil, being at once the heaviest and the most durable. This species of teak is used for the keel, timbers, and such parts of a ship as are under water; owing to its great weight, it is less suitable for the upper works, and is not at all fit for spars. The teak of Java ranks next to that of Malabar, and is especially suitable for planking. The Rangoon or Burman teak, and that of Siam, is not so close-grained or durable as the others; it is, however, the most buoyant, and is therefore best fitted for masts and spars. Malabar teak is extensively used in the building yards of Bombay. Ships built wholly of it are almost indestructible by ordinary wear and tear; and instances are not rare of their having lasted from 80 to 100 years. Such ships are said

to sail indifferently; but this is probably owing as much to some defect in their construction as to the weight of the timber. In Calcutta ships the timbers and framework are always of native wood, and the planking and deck only of teak. The teak of Burmah, being conveyed with comparatively little difficulty to the ports of Rangoon and Martaban, is the cheapest and most abundant of any. It is largely exported to Calcutta and Madras.

A species of timber called African teak, the produce of the *Oldfieldia africana*, is pretty largely imported into England from the west coast of Africa. Though destitute of several of the most valuable properties of teak, it is, for some purposes, a useful timber. [OLDFIELDIA.]

Teany, Tawny, or Brusk. In Heraldry, a colour compounded of red and yellow, employed in blazonry, but rarely met with in English coats of arms, and reckoned one of the dishonourable colours. In engraving, it is represented by diagonal and horizontal lines crossing each other.

Tears (the English word *tear* is identical with the French word *larme*: tracing *tear* through the earlier forms *taer*, *tehr*, *tehar*, *tæher*, we reach the Gothic *tagr*, for which we have the corresponding Greek words **δάκρυ**, **δάκρυμα**, answering to the Latin *lacryma*, which is softened into the French *larme*: the Sanscrit form of the word is [*d*]*asru*, from the root *dak*, to bite—Max Müller, *Lectures on Language*, second series vi.). The fluid which lubricates the cornea of the eye, when secreted in excess, forms *tears*; they are limpid, saline, perfectly miscible with water, and have a slight alkaline reagency, owing to the presence of free soda. Their principal saline contents are common salt and a trace of phosphate of soda, and they contain traces of albumen; but the whole solid matter scarcely amounts to one per cent. When the lacrymal duct by which tears are conveyed into the nostrils is obliterated, and they flow over the angle of the eye, they become concentrated by evaporation, and leave an irritating muco-saline crust. The exact nature, however, of the animal matter contained in the tears has not been determined.

Teazel (A.-Sax. tæsl). The Fullers' Teazel, used in the dressing of cloth, is the flower-head of *Dipsacus Fullonum*, a biennial plant of the order *Dipsacaceæ*.

Tebeth. The tenth month of the Jewish ecclesiastical year, and fourth of the civil year. It corresponds to December.

Technology (Gr. τεχνολογία). A term invented to express a treatise on grammar.

Tecoma (Tecomaxochitl, its Mexican name). A considerable genus of *Bignoniaceæ*, composed of tall trees inhabiting the tropical parts of America, and valued chiefly on account of their hard almost indestructible timber, which has procured for several species the name of Roble-Oak. The White Wood of the West Indies (*T. leucoxylon*), the Guayacan of Panama (*T. Guayacan*), the Porrier de la Martinique of the Caribbean Islands (*T. pentaphylla*), and several Brazilian species, might be particularly pointed out as yielding first-rate timber for house and ship building, or wood for making bows for savages. Several species are of importance in medicine. *T. impetiginosa* abounds in tannin; its bark is bitter and mucilaginous, and it is used in the form of lotions, baths, &c. in inflammation of the joints and debility. *T. Ipe* has similar qualities, and is prescribed by the Brazilians as a gargle in ulcers of the mouth. The leaves of *T. subvernicosa*, known also as *Sparattosperma lithotriptica*, are bitter, acrid, and diuretic, and have a Brazilian reputation in calculus. When young, the *Tecomas* often have simple or unifoliolate leaves; but as they grow up, the leaflets increase in number, and become digitate. The large flowers are arranged in terminal bunches, and in many species appear after the leaves have fallen off.

Tectibranchiates (Lat. tego, *I cover*, and branchia, *gills*). A name given by Cuvier to an order of hermaphrodite Gasteropods, comprehending those species in which the gills are covered by a process of the mantle, containing a shell, or enveloped in a reflected margin of the foot. For this name that of *Monopleurobranchiata* has been substituted by M. de Blainville.

Tectizite. A mineral of uncertain composition, but supposed to be a hydrous sulphate of peroxide of iron.

Tectorium Opus (Lat.). In Ancient Architecture, the plasterer's work used upon ceilings and interior walls; it was a composition of lime and sand, and differed from stucco, which was called *albarium opus*. Great pains were taken to prevent work of this kind from cracking, by crossing layers of reeds, coated with argillaceous matter, upon it before it was coated with paint.

Tectrices (a word formed from Lat. tego, *I cover*). The name of the feathers which cover the quill-feathers and other parts of the wing. [COVERTS.]

Tee. [UMBRELLA.]

Teeth (Sansc. dat.; Lat. dens, dentis; Gothic tunthus; Ger. zahn, *a tooth*; the Greek, ὀδούς, ὀδόντος, being in all probability the same word). Teeth, properly so called, are parts peculiar to the vertebrate animals, composed of organic matter, hardened principally by the phosphate of lime. They are fixed to the bones of the mouth, and serve to catch, kill, hold, pierce, cut, or crush the objects of food, being variously shaped accordingly. Substances composed of softer material, generally horn, perform the analogous offices in the invertebrate animals, and are usually called *teeth*; horny material is substituted for teeth in a few fishes, in chelonians, birds, whales, and the *Ornithorhynchus paradoxus*.

In fishes the teeth may be situated on the premaxillary, maxillary, mandibular, palatine, vomerine, pterygoid, hyoid, or pharyngeal bones. In a few instances they are implanted in sockets or *alveoli*, or they may be fixed to an osseous base which is attached by ligamentous substance to the oral bones; but most commonly they are immediately anchylosed, or joined by

direct continuation of bony substance, to the bones themselves which encompass the mouth.

In reptiles the teeth may be found on the palatine, pterygoid, or vomerine, as well as on the maxillary and premaxillary bones. They are generally anchylosed, or confluent with the substance of the jaws; but in the plesiosauri and crocodiles they are implanted in sockets.

In mammals the teeth are confined to the maxillary and premaxillary bones, are always implanted in sockets, and in this class only may be so fixed by more than one fang or root.

Teeth generally consist of three distinct substances; viz. dentine, enamel, and bone or cæmentum, also called *crusta petrosa*.

The texture of the dentine is minutely tubular; that of the cæmentum, of combined tubules and cells; the earthy material is arranged principally in the interspaces of these cavities, which have definite arrangement and proportions in different vertebrate genera. The enamel, in mammals, consists of hexagonal filamentary columns.

In the human subject the teeth are called, according to their figure, *incisors*, *canines*, *bicuspids* and *molars*. The same terms have been transferred to the teeth of the mammalia generally, except that those which are homologous with the bicuspids in man are called *premolars* or spurious molars. A tooth is divided into a crown, a neck, and a fang or fangs. Other shapes are signified by the terms *tusk*, *sectorial*, *tubercular*, *scalprarial* or *chisel-tooth*, &c.

The vascular bodies concerned in their developement are called *pulp* and *capsule*; the dentine or body of the tooth is formed by the former, the enamel and cement are due to the latter organ.

In most cases when the pulp has developed as much dentine as forms the full-sized crown of the tooth, it diminishes in size; and as it continues to exercise its function during the progress of its diminution, a gradually decreasing fang is the result. When the diminution of the pulp, instead of being general, proceeds from two or three parts, a corresponding number of fangs are extended from the crown. But sometimes the pulp retains its full size and activity during the lifetime of the animal, in which case the part of the tooth lodged in the socket presents the same size and form as the protruded crown, of which it is a direct continuation. The fore teeth of the rat, beaver, and other rodents are familiar examples of these constantly growing teeth. But this is not the only mode in which excessive wear and tear of the teeth is provided for. In the elephant, when one grinder is worn down, it is pushed out and replaced by a second of subsequent formation. These successional teeth are formed in the elephant, each in a cavity at the back part of the jaw, behind the tooth which they are destined to succeed. In other animals, again, the teeth which suit the size of the jaws when young are pushed out by others which are proportioned to the size of the full-grown jaws. These, which are termed *permanent teeth*, succeed the *deciduous teeth* in the vertical direction, being developed in the substance of the jaws above the deciduous teeth in the upper and below the deciduous teeth in the lower jaw. Other molars are usually added behind. As the deciduous series of teeth are generally developed in mammals at the period when the young animal is suckling, they are commonly called *milk teeth*; but as in some rodents deciduous teeth are formed and shed before birth, they might be termed *uterine teeth*. Thus teeth may succeed each other in the horizontal or vertical direction. In the human subject all the deciduous teeth are succeeded vertically; but the additional teeth follow each other from behind forwards. In mammals, a tooth has not more than one successor in the vertical direction, but in reptiles and fishes there may be many such.

It is a singular but constant fact, that in mammals the permanent molar always presents a more simple crown than the deciduous one which it has replaced; thus, in man, the quadricuspid milk grinders are succeeded by the permanent bicuspides. For *dental notation*, see SYMBOLS, ZOOLOGICAL.

Teeth of Wheels. Teeth of wheels are generally the means by which the power of the first mover is conveyed to the working point of a machine; and it is obviously of great importance that they should be of such a form that as little as possible of the original power may be lost in transmission, and that the impulse should be conveyed through the train of wheels with a uniform force.

In the formation of the teeth of wheels, the object aimed at is to give them such a curvature that the angular velocities of the two pieces working together shall maintain the same constant ratio in all positions of contact. In order to preserve the constancy of the angular velocity ratio, it is only necessary that the acting faces of the teeth shall have such a form that the normal common to the two surfaces in contact shall always divide the *line of centres* (i.e. the line joining the centres of the wheel and pinion) in a fixed point. Now, the teeth of one wheel being assumed to have any form whatever, it is always *geometrically* possible to assign the form of those of another so that they shall fulfil this condition, and, consequently, work together correctly; but the forms which are found to answer in practice are limited to a comparatively small number. In a straight rack the curve both of the root and point of the teeth should be cycloidal, in a wheel the root should be hypocycloidal and the point epicycloidal, and in an internal segment the root should be epicycloidal and the point hypocycloidal. In the workshop, the curves of the teeth are struck out by rolling the template of the generating circle on a template of the pitch line, when a scriber or pencil marks the curve. More usually, however, the teeth are struck out by compasses, the roots being radii of the wheel, and the points segments of circles

struck from the centre of the adjacent tooth on the pitch line. The best diameter of the rolling circle for any pitch is 2·22 times the pitch, and no wheel intended to work smoothly should have less than fourteen teeth. The pitch should be as fine as is consistent with the required strength. When the velocity of the motion exceeds $3\frac{1}{2}$ feet per second, the larger of the two wheels should be fitted with wooden teeth, the thickness of which should be a little greater than that of the iron teeth. The breadth of the teeth in the direction of the axis varies very much in practice; but where the velocity does not exceed 5 feet per second, a breadth equal to four times the thickness of the tooth will suffice, or five times the thickness if the velocity is greater, the surfaces being kept well greased. But if the teeth be constantly wet, the breadth should be six times the thickness. The best length of the teeth is $\frac{5}{8}$ of the pitch, and it should not exceed $\frac{3}{4}$ of the pitch. In the Soho practice the length of the teeth is made $\frac{4}{12}$ of the pitch outside and $\frac{5}{12}$ of the pitch inside of the pitch circle: in the London practice $\frac{3}{12}$ of the pitch are outside and $\frac{4}{12}$ inside of the pitch circle. About $\frac{1}{8}$ of the pitch should be left unoccupied at the bottom of the pitch for clearance.

If t = the thickness of tooth in inches, w the weight upon it in pounds, and c a constant multiplier, which for cast iron is ·025, for brass 0·35, and for hard wood ·038, then $t = c\sqrt{w}$. This formula put into words is as follows:—

To find the proper thickness of tooth of a cast-iron wheel to transmit with safety any given pressure.

Rule.—Multiply the square root of the pressure in pounds acting at the pitch line by the constant number ·025. The product is the proper thickness of the tooth in inches.

Example.—What is the proper thickness of the teeth of a cast-iron wheel moved by a pressure of 233·33 lbs. at the pitch circle?

Here $\sqrt{233 \cdot 33} = 15 \cdot 27$, and this multiplied by $\cdot 025 = \cdot 381$, which is the proper thickness of the teeth in inches.

Tegmenta (Lat. from tego, *I cover*). In Botany, the scales covering the leaf-buds of the deciduous trees of cold climates.

Tegument or **Tegmen** (Lat.). In Anatomy, the general covering of the body. In Entomology, the term is applied to the coverings of the wings of the order *Orthoptera*, or straight-winged insects.

Teil-tree (Lat. tilia). The Lime-tree, *Tilia europæa.*

Teinds (from *ten*). In Scottish Law, tithes. By the course of various usurpations, the whole teinds of Scotland had become vested after the Reformation in the crown; or in private individuals, termed *titulars*, to whom they had been granted by the crown, or to the *feuars* or renters from the church. By a succession of decrees and enactments these tithes were generally rendered redeemable at a fixed valuation; and the clergy are provided for by stipends, paid by the commissioners of tithes (when these are vested in the crown) or by the titular. The minister can seek the increase of these stipends by process of augmentation and modification; and, if augmented, every heritor becomes liable in proportion to the amount of his teinds.

Teinoscope (Gr. τείνω, *I stretch*; σκοπέω, *I look*). The name given by Sir David Brewster to an instrument otherwise called the *prism telescope*, formed by so combining prisms that the chromatic aberration of the light is corrected, and the linear dimensions of objects seen through them increased or diminished.

'If we take a prism, and hold its refracting edge downwards and horizontal, so as to see through it one of the panes of glass in a window, there will be found a position, viz. that in which the rays enter the prism and emerge from it at equal angles, when the square pane of glass is of the natural size. If we turn the refracting edge towards the window, the pane will be extended or magnified in its length or vertical direction, while its breadth remains the same. If we now take the prism, and hold its refracting edge vertically, we shall find, by the same process, that the pane of glass is extended or magnified in breadth. If two such prisms, therefore, are combined in these positions, so as to magnify the same both in length and breadth, we have a telescope composed of two prisms; but unfortunately the objects are all highly fringed by the prismatic colours. We may correct these colours in three ways: 1st, We may make the prisms of a kind of glass which obstructs all the rays but those of one homogeneous colour; or we may use a piece of the same glass to absorb the other rays when two common glass prisms are used. 2nd, We may use achromatic prisms in place of common prisms. Or, 3rd, what is best of all for common purposes, we may place other two prisms exactly similar in reverse positions.' (Brewster's 'Optics,' *Cabinet Cyc.* p. 363.)

Professor Amici, of Modena, has recently constructed a combination of prisms of the same glass, in which the chromatic aberration is corrected, and a power of about three times obtained. The plan is well suited for opera-glasses. Amici's teinoscope consists of four rectangular prisms, having their refractive angles different, and connected by pairs; the two pairs being similar, those next the eye or the first pair are vertical, and the second pair horizontal, so that equal refraction is produced in every direction. The distance between each pair is about an inch and a half. (*Library of Useful Knowledge,* 'Optical Instruments,' p. 55.) Sir D. Brewster (*Optics*, p. 364) states that this instrument had been made by Dr. Blair as well as by himself, before it was proposed or executed by Amici.

Tej-Bul. A North Indian name for the warm spicy capsules and seeds of *Xanthoxylon hastile.*

Tekoretine. A crystallised mineral resin found in fossil wood in Denmark.

Telamones (Gr. τελαμῶνες). In Archi-

tecture, colossal figures of men used for the purpose of supporting entablatures. [CARYATIDES.]

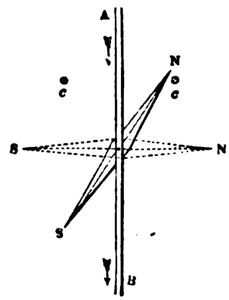
Telegram. A message transmitted by telegraph.

Telegraph (Gr. τῆλε, *afar off*, and γράφω, *I write*). The name given to a mechanical contrivance for the rapid communication of intelligence by signals. The term *semaphore* (Gr. σῆμα, *a sign*; φέρω, *I bear*) has been introduced by the French, and frequently adopted by English writers; but since the universal employment of the *electric telegraph* it has fallen into disuse. [SIGNALS, NAVAL.]

Telegraph, Electric. The electric telegraph, or, as it ought more properly to be called, the ELECTRO-MAGNETIC TELEGRAPH, has now superseded all other means of telegraphic communication. We purpose, therefore, briefly to describe the *principle* upon which these instruments are constructed, referring for minute details to the various works which have been published, and to the specifications of the many patents which have been issued upon the subject. The mutual relation of electric and magnetic currents will be evident from what has been stated elsewhere under the heads ELECTRO-MAGNETISM and GALVANOMETER, so that it will only be necessary to recapitulate such circumstances as have especial relation to telegraphic purposes.

When a current of voltaic electricity is traversing a metallic wire, a magnetic current is at the same time established, at right angles to, and as it were revolving about, the electric current as its axis; and if the pole of a magnet be supposed capable of freely moving in any direction, the tendency of such pole would be to revolve about the wire in question, or, rather, about the electric current which that wire carries. If a common magnetic needle, turning horizontally upon a point or pivot, be brought near the voltaic current, or to the wire conveying that current, the magnet will accordingly be deflected from its meridian. Supposing, for instance, the magnetic needle in its natural position, and pointing therefore north and south, to be approached by a wire transmitting the volta-electric current, held above, and parallel to the needle, the deflection of the needle will take place either to the right or left, or to the north or south, the direction of the deflection depending upon that of the electric current; and accordingly the tendency of the magnetic needle will be to place itself at *right angles* to the wire conveying the electric current. It is obvious, therefore, that the electric and magnetic forces may so far be said *to deflect each other*, and upon this principle the various forms of the galvanometer are constructed. Now, in reference to the application of such principle to telegraphic purposes, another form of apparatus must be adopted, in which the magnetic needle and deflecting current, instead of being placed horizontally, as in the galvanometer, are placed *vertically*, or perpendicularly, as in the annexed diagram, where A B represents a wire having a magnetised steel needle placed immediately behind it, and so adjusted as to hang vertically when at rest. If an electric current be now made to descend from A to B through

Fig. 1.



such wire, the needle will be deflected into the position N S; i.e. its north pole will turn to the right as the spectator stands before it; and on increasing the force of the electric current, the deflection of the needle might be so far increased as to cause it to place itself at *right angles* to the electric current, as shown by the dotted figure; but this may be prevented by the small studs *c c*, by which such extreme deflection is limited. If we now suppose the wire to be continued on, and bent up on the other side of the needle into the shape of the letter U, the current still passing onwards, i.e. down the limb A B and up B C (as indicated by the darts), then the portion of the current B C would also act upon the needle, and proportionately increase the deflection. If we now change the direction of the electric current, so as to send it down C and up A, then also will the direction of the deviation of the magnetic needle be changed, and its north pole, instead of pointing to the right, will point to the left. And if, by repeated convolutions of the wire, the electric current be made to pass many times around the magnetic needle, the deflection would be still further increased, so that, by the adoption of this latter expedient, or by the use of a *coil* instead of a single wire, the effect of the electric current may be so *multiplied* as to produce a considerable deflection by a comparatively feeble current. This is, in fact, the principle of the *galvanometric multiplier*, and is the form of apparatus used in the electric telegraph, as now most commonly constructed. The construction of this *coil* is shown in the annexed wood-cut. It consists of a polished

Fig. 2.

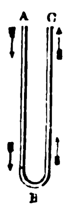
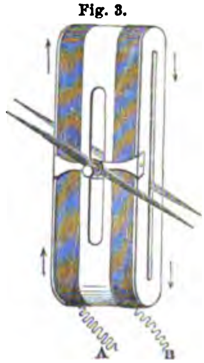


Fig. 3.



wooden or ivory frame, round which are bound some hundred feet of fine copper wire, covered with silk, which, being a non-conductor, prevents the lateral passage or transfer of electricity from wire to wire, so that the current, entering at A, passes through the whole length of the coil, and goes out at B. Two magnetic needles are fixed upon an axis which passes through the frame, one within, the other without the coil. The poles of these needles are in opposition to each other, and they are thus rendered *astatic*, i.e. they are not affected by the magnetism of the earth. This coil is so placed at the back of the dial plate of the telegraph, shown in the next diagrams, as to allow the outer needle to traverse right and left upon

Fig. 4.

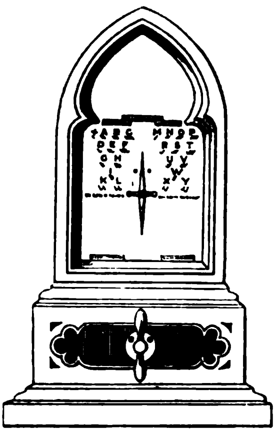
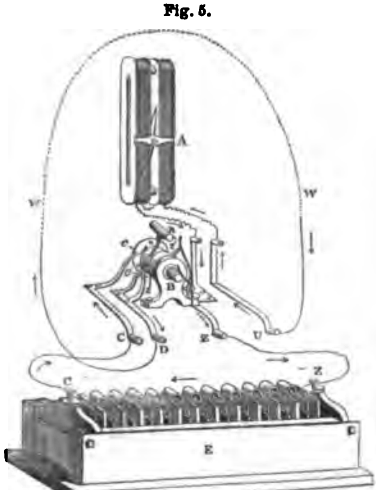


Fig. 5.



the dial plate. A more delicate instrument than the one now described is known as THOMSON'S GALVANOMETER. [TELEGRAPH, SUBMARINE.]

Having thus stated the *principle* upon which the usual form of the electro-magnetic telegraph is constructed, we may now further explain the details of its simplest form, in which *one* indicating needle only is employed, and which therefore is usually called the *single-needle instrument*. A front and back view of this telegraph is given in the preceding cuts, the battery being represented annexed to the lower, and the circuit through the galvanometric coil A being completed by the wire W W. The following description of the *working* of the instrument is abridged from Mr. C. V. Walker's *Electric Telegraph Manipulation*, to which we may here refer the reader for a variety of details respecting its construction and uses, which would have been irrelevant in this article.

The instrument has a twofold character: it is either *passive*, or ready for *receiving* signals *from* another instrument; or it is *active*, or ready for *transmitting* signals *to* another instrument. By describing first how it is fitted for *receiving* signals, and then how it is arranged for *transmitting* them, we shall be better able to analyse it, and comprehend its structure. The frame of the coil A (fig. 5) is screwed upon the face of the instrument, which face is a brass plate varnished on the inner side. Looking at the coil, a short wire from its *right-hand end* comes to a screw terminal, which, by a slip of brass, is connected with another terminal U. The *left-hand end* of the coil comes also to a terminal, from which a slip of brass descends to a brass plate, here partly hidden; but its form may be seen from a similar plate, visible on the left side. These twin plates are in metallic connection by means of the two upright *springs*, shown in the cut. The *springs* are of steel, and press strongly on two points in a short insulated brass rod *n*, which is screwed into the framework of the instrument. The left-hand plate is connected with the terminal D, also by a slip of brass. If, now, the two terminals U and D are connected by a wire W W, the circuit will be complete, as follows: from the terminal U into the coil at the right-hand side; out of the coil, at the left side, downwards to the right-hand plate; up the right-hand steel spring, across the brass rod *n*, to the left-hand steel spring: downward, by this spring, to the left-hand plate, thence by the slip of brass to the terminal D, and thence by the wire W W to the terminal U, whence we started. If, now, the wire from U went up the line of railway, and the wire from D down the line, and the circuit were in some way kept complete on the large scale, as it has been here described on the small scale, any electric current passing along the wire from a distant station would traverse this coil in its course, and would *deflect the needle*, and so make a signal.

So far for receiving a signal; now for sending one. Were we to go out on the open railway, taking with us a battery, and to cut any one of the wires, and place its two ends, thus obtained,

upon the two terminal ends of the battery, a current would pass along the line, and the needles on that line would be deflected; and if we changed hands, so as to reverse the connections, and consequently to reverse also the direction of the electric current, the deflections of the needles would be reversed. The same would happen were we to cut a wire inside the office, or inside the telegraph, and to treat it in a similar way. Now, in every apparatus contrived for transmitting signals, we have a *place corresponding to such a cut wire*; and near this place are the poles of the battery, mounted and movable, so that they may be readily applied in the breach, one way or the other as required. The place here (fig. 5) is the *top of the springs*. They are not *joined* to the brass rod *n*, but *press hard* upon it, and can readily be raised; and when either of them is raised, the circuit is broken. Now, near this place is a contrivance by which the poles of the battery may make a breach in the circuit, and be applied in the breach in either direction. The drum B is of box-wood, the ends *c* and *z* being capped with brass, and insulated from each other by the wood left between them. The drum is movable by a handle in front of the instrument, visible in fig. 4. A stout steel wire, c', is screwed beneath into the *c* end of the drum; and a similar wire z' is screwed above into the *z* end. These two wires are the poles of the battery, z' being connected with the zinc end, and c' with the copper, thus: from the copper end of the battery a wire is led to the terminal C; thence a slip of brass leads to a curved brass spring which presses on the drum at *c*; from the zinc end of the battery a wire goes to the terminal Z, and thence a slip of brass leads to a similar curved spring, pressing on the continuation of the *z* end of the drum, as shown in the figure. Whenever, therefore, the drum is moved, the steel wire z' will lift up one or other of the upright steel springs; it is now lifting up the right-hand one, and so breaks the circuit; but, by a little further motion of the drum, the wire c' will press upon the boss below, as shown in the figure, and thus there will be a battery-pole on each side of the breach, and a signal will be made on this, and on all instruments connected with it. From the peculiar arrangement of the drum, the motion can be changed as rapidly as the hand can move. The battery connections are shown exactly as they occur in practice; and the connections are such that if the right-hand spring is moved off, the needle moves to the right, and if the left, to the left. The needle on the face of the instrument always has its north end upward, and the needle within the coil its north end downward, so that, by the law elsewhere stated, if we look at the face of an instrument, and see the top end of the needle move to the right, we may be sure that in the half of the coil nearest to us the current is *ascending*.

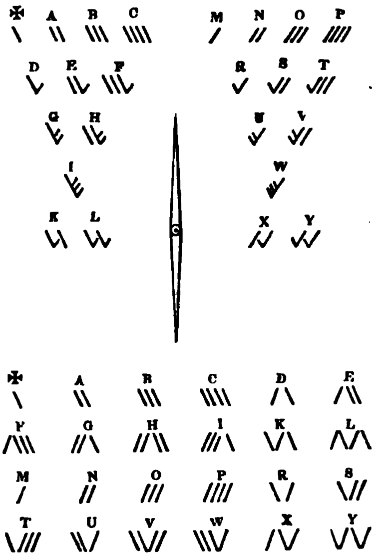
Now, as regards the *front* of the instrument, upon which the alphabet is engraved right and left of the needle, it will be obvious, from what has been said above, that the manipulator has it in his power to cause the dial-needle to vibrate or deflect to the right or left as he directs the electric current one way or the other through the coil, and this direction of the electric current is commanded in the way above described, by turning the handle at the lower part of the instrument to the right or left. When this handle is *vertical*, the current is altogether cut off.

The letters of the alphabet, and a few other signals, are indicated by the number of *beats* made by the needle, some of these beats being to the left and some to the right, the general rule being, that in the letters placed to the *left* of the needle the *last* beat to make any given letter is a *left-hand* beat, whatever other beats may enter into the production of the letter; thus, L requires four beats, and they are right, left, right, *left*, finishing with the *left*; so, again, the letters placed on the *right* of the needle finish with a *right-hand* beat, as, for instance, W, which is composed of four beats, three to the *left*, and the *fourth* to the *right*. The system upon which this single-instrument alphabet is formed is sufficiently simple. The symbol of each letter is placed underneath it, and consists of one or more diagonal lines sloping either to right or left, some of which are full length, and others half length; the direction of the diagonal is the direction of the deflection or beat, a deflection being made for each diagonal, the deflection corresponding to the *half length* being made *first*. D, for instance, is thus represented \/, and is made by a beat to the right, followed by a beat to the left; R is represented by ✓, and is made by a beat to the left, followed by a beat to the right; H is \\✓, two to the right and two to the left; W is ✓, three beats to the left and one to the right, and so on. The scheme of the code is: one, two, three, and four left-hand beats for the first four signals; then one right-hand, and one, two, and three left-hand beats for the next in order; then two right-hand and one and two left for the next; then three right-hand and one left; then a left, a right, and a left; and lastly, right and left, right and left, \/\/, which reaches L, and comprises the first half of the series. The other half are the counterparts, with the beats reversed. To render this description more intelligible, we give a separate representation of the dial alphabet, in which the direction and number of beats for each letter are shown separately.

In the following diagrams, the symbol like the Maltese cross ✠, indicated by one beat to the *left*, and which is termed *stop*, is used by the *sender* of a message, *at the end of every word*, and by the *reader* or receiver of the message, when he does *not understand* the previous word. On the other hand, a single beat to the *right* (indicating the letter M upon this form of the instrument) implies that he *does understand*. When, in this or other form of the needle tele-

graph, *numbers* are to be transmitted, which, however, is very rarely necessary in the form of *numerals*, conventional letters and signals are settled upon for the purpose.

Fig. 6.



Our object here is, merely to render the principle of this form of the electric telegraph intelligible, and therefore we have selected the simplest instrument; but at all the principal stations a DOUBLE-NEEDLE INSTRUMENT is employed, which may, in fact, be regarded as two single instruments capable of being worked separately or together. With this double telegraph the reading of the signals is much more rapid, but it has the inconvenience of requiring a separate line-wire for each needle; the signals also are different from those of the single instrument, but the *principle* is in both the same.

It is obvious, from the laws which govern the transmission of what we call the *electric current*, that when, by its means, a message is to be sent to any distant station, as, for instance, from London to Dover, there must be a means by which the current may return from Dover to London, and this was formerly effected by a separate wire; so that each single telegraph required two wires, one down the line to Dover, and one up the line to London, and a double-needle instrument could only be worked by four wires, by which much expense, and occasionally inconvenience, was incurred. But, about the year 1837 it was discovered that the circuit might be completed, or at least that the return-wire might be superseded, by what has been called the *earth circuit*, so that, instead of using *two* lengths of wire, one only is employed for each needle, and the terminal or return wire of the Dover instrument is connected with the earth at Dover, while the other terminal of the London instrument is similarly connected with the earth at London, and, strange to say, it is found that this transit by the earth is more perfect, *i.e.* presents less resistance to the passage of the electricity than if a return-wire had been used. This statement will, perhaps, be rendered more intelligible by the annexed cut, in which the

Fig. 7.

insulated line-wires proceeding from London at L to Dover at D are shown following the line of railway, whilst the dotted line between the buried copper plates R R (or gas or water pipes at each extreme) shows the supposed direction of the electric current in completing the circuit. Every telegraph station is thus provided with an *earth-plate.* Although the conducting power of the earth between R and R is many thousand times less than that of copper for equal sectional areas of conductor, yet the sectional area of the earth exceeds so enormously that of the copper or iron wires employed in telegraphy, that the return current is thus conveyed with far less resistance than would be the case if a separate wire were provided for its transit; indeed, some have discarded altogether the notion of *conduction* in these cases, and have regarded the earth as a reservoir in which positive and negative electricity are equally and indifferently lost, absorbed, or neutralised; the positive end of the battery freely giving off positive electricity to the earth at London, and the negative end giving off negative electricity to the earth at Dover, or vice versâ, as the case may be.

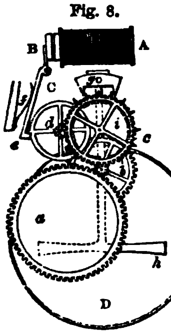
We have now endeavoured to render intelligible the principle upon which signals are communicable between distant stations by electro-magnetic means, and have only to notice a few of the appendages, as they may be termed, to the talking part of the apparatus.

One of them, and an important one, is the *alarum*, or *bell signal*, by which *audible* notice is given from station to station of their desire to talk to each other through the telegraph. These bell signals may be either altogether independent of the telegraph, and rung by a separate wire, or they may be rung by the same wire which actuates the telegraph, and which in that case is so arranged that the electric current may be diverted through the bell magnet, or through the telegraph, as occasion may require; and in this case, if we suppose the bell to be in the circuit, its *ringing* announces the wish of the distant station, say of Dover, to communicate with London; then London, on hearing the bell, turns on the current to the bell at Dover, to announce that the signal has been successful; the current is then turned off the bells on to the

needle-coils, and the message transmitted in the usual way. When separate and independent wires and bells are employed, they are always in the circuit, and may be rung whenever required. For particular purposes the bells may serve as special signals; and when rung once, twice, thrice, and so on, may thus serve to announce something that has happened at the distant station.

These *alarums* are rung by means of an *electro-magnet*, i.e. a short rod or core of *soft iron*, wound round with a sufficient length of silk-covered copper wire; this core becoming a powerful magnet whilst an electric current is traversing its copper coil, and returning again to its indifferent or normal state the moment that the electricity ceases to circulate. A side view of an *alarum* is given in the annexed diagram. A is the electro-magnet; in front of it is a soft iron keeper B. This keeper is attracted by the poles of the electro-magnet *every time* a current is made to circulate around it, and *as long* as it is in circulation; and attraction ceases the moment the current ceases. To prevent the keeper remaining attracted, which sometimes happens, even after the force ceases to circulate, it is prevented from actually touching the pole of the magnet by two ivory studs, or sometimes merely by the intervention of a piece of paper; but it is so adjusted that, when in its state of rest, it shall be as near as convenient to the poles of the magnet. The

Fig. 8.

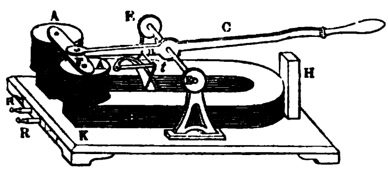


rest of the figure represents the mechanism by which the bell is rung. The keeper B is mounted on the shorter arm of a lever C; the other end of the lever terminates in a catch *e*, which catches a pin in the circumference of the wheel *d*, and prevents it moving; *f* is a slender spring pressing against the long arm of the lever C, by means of which the keeper is restored to its normal position when attraction ceases, and the catch *e* is made to act; *a* is a box containing the mainspring; *b*, a toothed wheel connected with *a* by a pinion; *c*, a toothed wheel having a pinion working in *b*; *d*, the wheel that carries the stop, and connected by its pinion with *c*; *g* is an escapement, working in pallets on the wheel *i*, which is on the same axis with the wheel *c*; *h* is the bell hammer: it is virtually a short pendulum, its connections and action being quite similar. When the voltaic current is made to pass along the wire of the coils A, the soft iron core is magnetised, and the keeper B is attracted; this raises the catch *e*, and so allows the wheel *d* to move. The machinery being thus liberated, the mainspring in the box *a*, which is kept wound up, sets it in motion, and the pendulum hammer *h* vibrates rapidly and strikes the bell D, which is shown also in section. When the magnetisation ceases, with the cessation of the current, the catch *e* is pressed into its place again by the reacting spring *f*, and the ringing terminates.

It will be seen, from this description, that the alarum is sounded by ordinary mechanism, and that the office of the voltaic force is merely to move a lever and liberate the machinery; whence it is obvious that there is little limit to the amount of noise which may be produced.

In some other forms of telegraph, the bell, instead of being sounded by the detachment of a common ringing scapement, is rung by the direct blows of a hammer attached to the keeper of the magnet itself; and there are several modifications of this contrivance, by which a single blow or a continuous ringing may be effected. For ringing bells at short distances, and in cases where a voltaic battery would be inconvenient, a current of magneto-electricity is substituted, which is most simply obtained by the following form of apparatus: A A are coils (similar to the coils above described); the two bars of iron which pass through the coils are connected by their upper ends to a strip of iron F, the lower ends resting on the magnet B; thus they form what is commonly termed a keeper, by connecting the two poles of the magnet; F is joined to a lever C, which

Fig. 9.



is attached to a shaft that works in bearings E E; the spring seen under lever C is for forming a short circuit; *n*, a small ivory pin for insulating the wire *t*; R R, two terminals, where the wires coming from the coils terminate; H, a block for stopping the entire descent of lever; K is the stand, to which the whole apparatus is firmly fixed. As long as the iron bar remains on the magnet, no effect is produced; but sharply depressing the lever whereby the iron bars are detached from the magnet, a current of electricity is produced, passing through the coils and along the line to the bell.

Such is an outline of the principle and construction of the electric telegraph ordinarily employed in this country; but the instruments,

and even the mode of producing the electric current, are susceptible of endless modification; thus, in the so-called *magnetic telegraph*, permanent magnets are made to evoke the necessary current. Conspicuous alike in the early history and in the latest developements of this magnificent invention, Professor Wheatstone has recently constructed instruments of the most ingenious construction, which are not only capable of working with electric currents, produced by a mere pocket magnet through sixty miles of wire, but which also print off the messages upon a strip of tinfoil in plain Roman characters. These instruments are especially adapted and now extensively used for private telegraphy. The printing telegraph deposits its messages unseen in a locked box, where they await the arrival of the owner should he not be present to receive them, thus dispensing with the employment and constant attendance of a receiving clerk. In another telegraph, patented by Professor Wheatstone, a hand points to the letter itself on a dial, the message being read off by pressing a stud near the letter. A company has been established to erect and maintain wires in London and the principal provincial towns for private use. Thus, a merchant at his suburban residence can have constant communication with his offices in town by instruments which are always ready for use, and which require no batteries or chemicals, the only power used being that necessary to rotate a small magnet, an amount of mechanical force easily applied even by a child.

In the bell telegraph of Sir Chas. Bright, the signals of the Magnetic Company's needle instrument are given by strokes upon two bells of different pitch, one of which represents the movements of the needle to the left, the other the movements to the right. We have also the printing telegraphs of Morse and Bain, which record the signals received in an alphabet composed of dots and strokes. Morse's system is generally employed throughout Europe.

There are also other kinds, all of which exhibit the most surprising ingenuity. The first is the printing telegraph of Mr. Hughes, a marvel of mechanical skill. The second is the pantelegraph of the Abbé Caselli, who, not content with the transmission of autographic communications, will send, with admirable precision, a portrait. This is accomplished by the aid of two pendulums, having a movement absolutely synchronous. One of the pendulums carries a pen or pencil of fine platinum wire (in connection with the line and the line battery) over the surface of the despatch or drawing, previously written or executed in insulating ink upon a metallic paper. The other, at the corresponding station, carries an iron pencil, likewise in connection with the line, over a paper prepared with a solution of the yellow cyanide of potassium. The electrical circuits are so disposed, that when the platinum point in its passage over the original writing or drawing touches the metallic surface of the paper, there is no emission of current along the line; while, on the other hand, when the point touches the insulating ink, an emission of current takes place, and the iron point passing at the other end of the line over the prepared paper leaves upon it a blue mark. This movement of the two pendulums being precisely equal, the reproduction of the drawing or despatch is absolutely exact.

The third is the type-printing telegraph of the Chevalier Gaetano Bonelli, the former director of telegraphs in Italy, and the inventor, among other beautiful applications of electricity, of the electric loom. It is to M. Bonelli that we are indebted for the bold idea of uniting the science of electricity with the art of Gutenberg, and of practically demonstrating that an ordinary typographic composition, fit for local use, may be unerringly reproduced at almost any distance. From this idea naturally arose the conception of converting the telegraph stations upon the main lines into so many type-setting workshops, of suppressing altogether every kind of delicate mechanism, of putting aside conventional alphabets, those pregnant sources of error—in a word, of reducing telegraphic science to a simple craft, within the reach of the most ordinary intelligence. Independence of synchronic movement or elaborate clockwork, freedom from all delicacy in the mechanical detail, and the substitution of the most absolute simplicity in the place of that which, until now, demanded a special knowledge to keep the machines in working order, are among the practical advantages obtained by Bonelli's system; while, on the other hand, a rapidity and certainty, never even hoped for, are insured. The principal features of this machine are two tables in cast iron, placed inversely to each other at the corresponding stations, and each provided with a miniature railway, over which run two waggons, one carrying the type-set message, the other the paper, chemically prepared with nitrate of manganese, and two combs, formed of the extremities of the wires of the line, one of which touches the type at one station, while the other passes over the prepared paper at the other—a spring-catch to each of the waggons setting them free to move by the closing of an electrical current. Neither on short circuit nor at a distance has the slightest difficulty been experienced in working the Bonelli machine—a well-considered system of counter-currents having completely annihilated the inconveniences which, from the time of Bain to the present moment, it had been impossible to avoid in electro-chemical telegraphy. Caselli was the first to conquer the difficulties which rendered the chemical process useless at a distance. Ten type-setters under Bonelli's system can compose at least 300 despatches per hour, and these may be transmitted in less than that time. As regards rapidity, Bonelli's telegraph has the advantage of three to one over the system universally adopted,

and has further this immense superiority, that all errors are avoided, and the necessity of repeating figures and proper names is entirely done away with. It has been asserted that an unattainable identity in the electrical condition of the five wires is absolutely indispensable to the well-working of the system. The wide differences of insulation in the line between Manchester and Liverpool has proved the contrary, actual practice having shown that a variation of from 40° to 50° in the amount of loss to earth does not make the slightest appreciable difference in the legibility of the printing.

When telegraphic lines are of great length, a serious obstacle to the transmission of signals arises. It is found that in long aërial or submarine lines, the speed at which distant signals can be sent is much diminished, the retardation increasing as the *square of the length of the line.* On a land line 2,000 miles long, consisting of iron wire one-fourth of an inch in diameter, the maximum rate at which a message can be sent is about 20 words a minute; hence on a line 1,000 miles long, a speed of 80 words per minute might be obtained; and on a line 500 miles, 320 words a minute would be distinctly transmitted. But as the maximum speed in telegraphing is about 50 words a minute, the retarding influence is only felt on extremely long unbroken lines, and more especially on those laid in the earth or sea, such, for example, as the Atlantic cable.

The cause of this retardation is what is termed *lateral induction.* When an electric discharge is sent into a Leyden jar, the electricity on the inner surface acts through the glass upon the neutral outer coating, charging it with the opposite electricity by influence or induction. If, now, an open glass cylinder of indefinite length be imagined coated within and without by tinfoil, and an electric discharge be sent at one end into the inner coating, the discharge will be propagated and expended in two directions—*onwards* in the interior by conduction, and *laterally* through the glass to the exterior by induction. Now, in this arrangement, the progress of the former involves the latter, and as time is required for induction to take place, the discharge will be greatly retarded in its progress by the influence of the outer conducting surface. Moreover, if a single discharge be sent into the coated cylinder, no free electricity will be apparent at the far end, until the entire outer coating has been inductively charged with the opposite electricity. When thus charged, if the two coatings be joined by a conductor, the opposite electricities combine, and the discharge takes place.

A similar effect takes place when an electric current from a voltaic battery is sent into such a Leyden arrangement, and just such a system is a telegraph cable. The conducting wire corresponds to the inner coating of the Leyden jar, the insulating material with which the wire is covered corresponds to the glass, and the earth or water surrounding the cable to the outer coating. Thus, a coil of submerged cable may be charged and discharged precisely like a Leyden jar. Owing, then, to the act of induction, a signal takes a certain time before it is apparent at the remote end of a cable; and before a second signal can be sent, a further time must elapse in order to discharge the line. It is mainly on this account that the speed of transmitting distinct signals through long lines is so limited. In a long aërial line, the air between the wire and the ground plays the part of the insulator, and the lateral induction is far less than in cables.

No way has yet been found of preventing this lateral induction; but its retarding influence has been diminished by the use of a *key,* or make-and-break, of peculiar construction. This key has a double action. By pressing it, the telegraphic line is first put in connection with one of the poles of the battery, and then immediately with the ground. The first contact charges the cable, the second allows it to be discharged. On the rapidity with which the cable can be charged and discharged, and successive pulses of electricity caused to follow each other without commingling, depends the *speaking power* of the cable. By the use of this double-acting key, the *operating power* of the Atlantic telegraph was said to be increased one-half; so that at present six to seven words can be transmitted through each of the Atlantic cables in one minute. [TELEGRAPH, SUBMARINE.]

Telegraph, Marine. An instrument used in ships and steam vessels to convey the orders of the captain, when standing in a high position near the middle of the ship, to the steersman and to the engineer. The forms of apparatus used for these purposes are very various. In some cases an electrical mechanism is used, which causes a hand at one end of a wire to follow the motions of another hand situated at the other end, and which is moved by the captain into the position necessary to point out on a circular dial the particular order which he wishes to have obeyed. Usually, however, the engineer's telegraph consists of a vertical spindle with a handle and dial on its upper end, and a corresponding dial with hand at its lower end, in the engine room. Thus when the captain moves the handle into the position answering to the particular order which he wishes to give, by the same operation he rings a bell so as to draw the engineer's attention to the altered position of the hand. To direct the steersman, three labels, one indicating *port,* another *starboard,* and another *steady,* are exhibited near where the captain stands, and at night these are exchanged for different coloured lights, and by the nature of the light or label exhibited the steersman is guided in moving the helm.

Telegraph, Submarine. A cable composed of a core of copper wires insulated by Indian-rubber, gutta percha, or other non-conducting material, and protected by tarred hemp, and generally by external iron wires.

This cable is laid along the bottom of the sea, and through the insulated wires telegraphic messages are transmitted. Submarine telegraphs have been in successful operation in narrow tracts of water for many years. But the successful establishment of two different lines across the Atlantic constitutes a new epoch in the art, and as these telegraphs may be expected to constitute the type of such lines of communication in the future, it will be sufficient here to describe the principles and material features of those undertakings.

'The problem,' to quote from an admirable article contributed to the *Popular Science Review* for October 1866, 'may be stated thus: Given the two poles of a galvanic battery at Valentia, it was required to provide a path from one to the other, which, though reaching to the other side of the Atlantic and back again, a distance of some 3,500 miles, should offer less resistance to the passage of an electric current than any other possible route by which it could traverse the few feet or inches by which the two poles were separated. For this purpose it was necessary, in the first place, to diminish as much as possible the resistance which would be encountered by a current passing from one pole of the battery to Newfoundland, and returning thence to the other pole; and, in the second place, to make as great as possible the resistance offered to the passage of the current from one pole to the other by any shorter path.

'The first of these objects was effected by extending between Valentia and Newfoundland a copper wire, pure copper having the smallest electrical resistance of any substance known, with the exception of silver. When the Irish end of this wire is connected with the positive pole of the battery, and the other end of the wire and the negative pole of the battery are at the same time each of them connected with a large metallic plate (called an *earth-plate*), either buried in the ground or sunk into the sea, the current starting from the positive pole passes along the wire to Newfoundland, then through the Newfoundland earth-plate into the ground or into the ocean, and so back through earth or water, or both, to the Valentia earth-plate and the negative pole of the battery. This conductor is formed of a strand of seven wires, each of them 0·048 inch in diameter, and therefore together equivalent to a single wire of nearly 0·144 inch diameter. Its length, as laid, is about 1,858 knots, and each knot has an electrical resistance at 24° C. or 75° Fahr. equal to 4,272 times the unit or standard of resistance adopted by the Committee of the British Association on Electrical Standards, and known as the *British Association unit*; consequently, the resistance of the whole length of the conductor may be taken in round numbers as equal to 7,500 B.A. units, allowing for a diminution of resistance caused by the low temperature of the bottom of the Atlantic. . . .

'Let us try to put this comparison between the resistance of the conductor and that of its insulating coating into a more exact form. We have already estimated the former at about 7,500 B.A. units; a statement by Mr. Latimer Clark, in the *Mechanics' Magazine* for the 10th of August, enables us to estimate the latter According to this statement, the resistance to the escape of electricity from each knot of the conductor through the gutta-percha covering into the ocean may be represented by 2,200,000,000 B.A. units; consequently the resistance to the escape of electricity from the whole 1,858 knots of the cable will be equal to $\frac{1}{1858}$ of 2,200,000,000, or 1,180,000 B.A. units; or, in other words, it is about 157 times more difficult for an electric current to find its way back to the battery by taking a short cut across the gutta percha into the water, than by traversing the whole distance from one end of the cable to the other and back by the way prepared for it.'

We now come to the engineering part of the undertaking,

The first attempt to lay a submarine cable across the Atlantic was made in 1857 by the Niagara and Agamemnon. That cable had a central core formed of seven copper wires of No. 22 wire gauge, laid six round one, and insulated by three layers of gutta percha. The insulated wires were protected by a serving of tarred hemp surrounded by eighteen strands of charcoal-iron wire, each strand being composed of seven wires of 22½ wire gauge. The weight of this cable per knot was in air 20 cwt. and in water 13·4 cwt., and its contract breaking strain was 4·85 times its weight per knot in water. The total length of cable shipped was 2,174 knots. After various failures in 1857 and 1858, the cable was at length laid and messages were transmitted through it. But the transmitting power soon ceased, from some unexplained cause. It was found, however, by subsequent experiment that the insulating power of gutta percha was much impaired by being subjected to a great pressure of water.

In 1864, a new cable was manufactured with seven copper wires of No. 18 wire gauge embedded in Chatterton's compound, and insulated by the application of four layers of gutta percha alternated with four layers of Chatterton's compound. Great care was taken in the selection of the copper, as it was found that different specimens varied in conducting power as much as 85 per cent., the presence of arsenic being especially prejudicial. It was stipulated that the conducting power of the copper employed in the construction of the Atlantic cable should not be less than 15 per cent. inferior to that of pure copper, and all the copper used was carefully tested to determine its conducting power. The diameter of the core or assemblage of insulated wires was ·464 inch, and its weight per knot was 400 lbs. The core was surrounded by a padding of soft jute yarn saturated with a preservative mixture; and around the covering of jute ten wires of Webster and Horsfall's homogeneous metal, ·095 inch diameter, each wound round by five strands of Manilla hemp saturated with the

preservative mixture, were spirally wound, forming the protective covering of the cable, which had a breaking strength of 7 tons 15 cwt. Its weight per knot in air was 35 cwt. 3 qrs. and in water 14 cwt. Of this cable 2,400 miles were shipped in the Great Eastern to connect Valentia and Newfoundland, 1,640 miles apart; and on June 24, 1865, the Great Eastern left her moorings in the Medway, and began to lay the cable on July 23. But after a considerable length of cable had been paid out it broke, and the attempts made to recover the broken end failed. Owing to the advanced period of the year, and the defects of the grappling apparatus, the vessel had to return.

Nothing daunted, however, by this want of success, the telegraph company proceeded to manufacture a new cable, of which the core is exactly the same as that of the cable of 1865. The protective covering consists of ten wires of ·095-inch diameter, drawn from Webster and Horsfall's homogeneous iron and galvanised, and each wire is wound round by five strands of white Manilla yarn. These wires are wound spirally round the core, which is padded with ordinary hemp soaked in a preservative mixture. The weight of this cable, known as the 1866 cable, is 14¾ cwt. per nautical mile in water and 31 cwt. in air, and its contract breaking strain is 12 times its weight per knot in water. The paying-out machinery consisted of six grooved or V wheels, the shafts of which were fitted with brakes, and the cable was pressed into the grooves by six riding wheels, the shafts of which were also fitted with brakes and were kept down by levers loaded with weights. These wheels served to keep the cable tight on the paying-out drum, which was 6 feet 1 inch diameter and 1 foot broad. The cable made four turns round this drum, and was prevented from over-riding by suitable directors. From the paying-out drum the cable passed over a dynamometer wheel, which deflected it by a lever loaded with weights, and thence it passed over a V wheel overhanging the stern, being sustained in that position by strong projecting girders. The cable issued through a bell-mouthed casting intended to prevent chafing against the flanges of the V wheel.

The Great Eastern, thus fitted, started on June 30, 1866, on her mission to lay the cable. Having succeeded perfectly in this task, she proceeded to pick up the end of the 1865 cable, in which also she succeeded, and, a splice being made, the residue of that cable was also laid, two lines of submarine communication being thus opened between Europe and America. The paying-out machinery for laying the 1866 cable was fitted with a pair of trunk engines, made by Messrs. John Penn and Son, capable of working up to eighty horse-power, for the purpose of hauling in the cable, if that operation should be found necessary to discover a flaw, or otherwise. Picking-up gear, connected with two similar engines, was fitted to the bow of the vessel, and this gear was made very much stronger than that employed in 1865. There can be no doubt that submarine telegraphs will now be carried through every sea; and the experience which has been acquired in the construction and laying of these telegraphs will divest such enterprises of the speculative and precarious character hitherto attaching to them. The instrument employed for receiving electric signals through the Atlantic telegraph lines is a reflecting galvanometer, of the exact form drawn and described under the article THOMSON'S GALVANOMETER.

Submarine telegraphs are examined and repaired, when necessary, by the aid of a steamer with proper gear for raising the cable to the surface, and paying it out again after the repair has been effected. A large sheave, from 2 to 3 feet diameter, and 8 to 12 inches broad, formed with deep flanges, is supported by cantilevers over the bow of the vessel, and cast-iron cheeks are fixed to the cantilevers to prevent any rope which passes over the pulley from slipping out if drawn sideways. A picking-up pulley or drum, 6 or 7 feet in diameter, and 12 to 15 inches broad, is set in the fore part of the ship, and this pulley is driven by an engine usually of about twenty horse-power, but more in the case of cables laid in deep seas. Three or four turns of the grapnel rope or cable are taken round this drum, which, being put into revolution by the engine, hauls the rope in, and a stationary piece of iron or steel is so placed as to press the turns of the cable endways on the drum during its revolution, so as to shift it over, or *fleet* it, as the technical phrase is. In some cases this drum overhangs; in other cases it is supported by a bearing at each end, but the former arrangement is the more convenient. A similar drum with a proper break is usually fitted at the stern for paying the cable out as it is repaired. Sometimes a cable is under-run by passing a pulley under it, set in a stirrup hanging over the bows; but this can be done only in shallow seas. For grappling a cable, short grapnels with four prongs, weighing from 30 to 60 lbs., are commonly used—two of the prongs necessarily engage the ground—and a piece of ¾-inch chain, 20 or 30 fathoms long, is attached to the grapnel, to which in turn is fixed a 6 or 8 inch drag rope. In shallow water, the length of drag rope is made three or four times the depth, but the Atlantic cable was hooked with a length of only one-fifth more than the depth.

It would be impossible within the limits of this article to notice the various methods of constructing submarine telegraphs which have been propounded by different inventors. It may be stated, however, that Mr. Siemens has made some good telegraphs by insulating the wires by ribands of Indian-rubber. One of these is laid above and the other below the wire; and the edges being cut off by circular shears, the cut edges when pressed together by rollers cohere. Similar ribands are then applied over the first, but breaking joint with them. A tape saturated

with a substance impervious to water is then laid on spirally. Three insulated wires and three strands of hemp are then made into a cable, over which is laid a sheathing of hemp, and finally a serving of galvanised wires. Mr. Hooper also insulates his wires with Indian-rubber, which he vulcanises by exposing it for some hours to a heat of 280° Fahr. after it has been applied to the wires. It is alleged that greater durability is thus obtained, and it has been proved that the insulating power of such a coating is at least forty times as great as that of gutta percha.

Telemachus. [Phaethon.]

Teleology (Gr. τέλος, *an end*, and λόγος). The doctrine of final causes is so called. The *teleological argument* for the existence of a Deity is derived from those marks of design apparent in the universe, which not only imply an intelligent Creator, but demonstrate at the same time His moral attributes. When these are derived from material nature, the argument is styled *physico-theological*. The reader will find in Whewell's *Bridgewater Treatise* an explanation of Bacon's meaning in banishing the doctrine of final causes from the domain of physical science.

Teleosaur (Gr. τέλειος, *perfect*; σαῦρος, *a lizard*). The name of a genus of fossil Saurian reptiles, resembling the *Gavials*, but having the vertebræ united by flat surfaces, instead of ball-and-socket joints. Fossil Crocodilia exhibiting this character ranged from the lias to the chalk inclusive.

Telephassa (Gr. Τηλέφασσα). In Greek Mythology, the wife of Agenor, and mother of Cadmus, Europa, and Phœnix. In some versions of the myth she is the wife of Phœnix, while the wife of Agenor is Antiope. In the common legend, when Europa was carried away by the white bull, Telephassa with Cadmus sought her lost child over land and sea, until at length she sank down in the weariness of death on the Thessalian plain. She is thus a being who moves from east to west, seeking for something which has gone before her, but never attaining to it. This simple tale is chiefly valuable as containing names which explain themselves. Her home is in Phœnicia, the purple land, in which dwells Phœnix, the same mythical being who in the *Iliad* is the teacher of Achilleus, and who for the benefit of the hero recites to him the story of Meleagros and Atalantê. Her name, signifying literally *that which shines from afar*, describes the shooting rays of light which dart across the heaven in early morning. Thus Telephos answers to Telephassa, the same idea being expressed in the name Telemachus. [Odysseus.] The word Europa, like many other mythical names, describes the broad flush of light which overspreads the sky before the rising of the sun; to this class belong such names as Euryphassa, Euryanassa, Euryganeia, Eurydikê, Eurymedusa, Eurytos, Eurynomê. A still larger class of names expresses the simple notion of light or splendour, as Phaethon, Augê, the mother of Telephos; Phaëthusa and Lampetiê, the children of Neæra, the early morning, who tend the cattle of Helios in Thrinakia; Autolycus, the grandfather of Odysseus; and Pasiphaë, the wife of Minos. In many cases a confusion has arisen between words denoting light and the names of beasts, which, however, belong not improbably to the same root. Thus, the myths of Arcas and Arcturus [Rishis], which denoted originally the bright and glistering stars, have been modified, like those of Lycaôn, by tales of transformation into bears and wolves—a point which should perhaps be taken into account in attempts to trace to its source the superstitions concerning Lycanthropy. The name Lykios, as applied to Phœbus, the light-giving god, retained its signification of brightness; but the way in which Æschylus plays on the two meanings of λευκός, *brilliant*, and λύκος, *a wolf* (*Sept. c. Theb.* 145), illustrates the method in which these tales of metamorphosis grew up. Names expressing only brightness became, in the same way, geographical designations of countries; but Lykia, or Lycia, like Phœnicia, Delos, and Ortygia, were all names of the Eastern or Morningland, which lay to the east of those who applied these names, as the Hesperian lands lay always to the west. The list of self-interpreting names may be extended indefinitely; and when these names occur in legends which are manifestly solar, as in that of Endymion and Selênê, or in the stories of beings who belong to the large class of solar heroes, as Perseus, Theseus, Œdipus, &c., they tend at each step to strengthen the position that mythology had its origin in phrases descriptive of sensible phenomena. Thus, Telephos is the son of Augê or *light*; Theseus, of Æthra, *the air*; Œdipus, of Iocastê, who, like Iolê, Iobates, Iamos, &c., embodies the violet hue of the morning sky; Phrixus and Hellê, of Nephelê, *the mist*, in the tale of the Golden Fleece. Other names, again, denote the light which springs up in the east as the sun sinks down in the west, whether by the reflected flush of solar light, or by the rising of the moon; thus, Antigone, the being who rises opposite (ἀντί), cheers Œdipus in his last hour: and the same idea is expressed not less clearly in the name Antiope. The names here mentioned explain themselves: others, as Erinys, Procris, Sarpêdon, Kephalos, Hermes, Achilleus, Ixion [Tantalus], become clear on a comparison with Sanscrit names, and with passages in the Veda which throw light on the origin of legends as complicated as those of the Trojan war.

Telephos (Gr.). In the mythical genealogy of the Arcadians, a son of Heracles and Augê (*the light*). His name, like that of his mother, belongs to that class of names in mythology which explain themselves [Telephassa]; and the incidents of the tale, in their many conflicting versions, likewise illustrate the solar character of the legend. Like Paris and Œdipus, he is exposed on a hill side, and, like them, he is guarded or suckled by a wild beast. Like Œdipus, he consults the Delphic oracle to know where he may find his parent, and, in harmony

with the old mythical speech, he is bidden to seek for Augê in the eastern land of Mysia. There, accordingly, he finds her, and becomes the husband of Argiope, another name denoting simply brightness.

Other versions related that Teuthras, king of Mysia, sought the aid of Telephos, promising to give him his daughter Augê in marriage; and thus the story of Œdipus and Iocastê is imported into the myth, with this difference, that Augê refuses to agree to the marriage and threatens to murder her future husband, who, by the intervention of Heracles, learns that Augê is his own mother. This is manifestly only a device to reconcile the story with the ethical sentiment of a later age.

During the reign of Telephos, Agamemnon led the Achæans against Troy. When they entered Mysia, they were repelled by Telephos, whom Dionysus caused to stumble over a vine; Achilleus was thus enabled to inflict on Telephos a wound which, like those inflicted by the arrows of Heracles, could not be healed: incurable wounds being hence called τηλέφεια τραύματα. But again consulting an oracle, Telephos was told that his wound might yet be healed, but only by him who had inflicted it. Having stolen Orestes from his cradle, by the advice of Clytæmnestra, he secured the aid of Agamemnon; and thus Achilleus was persuaded to heal Telephos by rubbing the wound with rust from the spear which had inflicted it. This revivifying power is ascribed to other mythical beings: thus, when PARIS is wounded by Neoptolemus, one legend says that Œnone whom he had deserted would not heal him; while another says only that she could not, although she longed to do so. This last tale is only a modification of the phrase, that Endymion must sink to sleep, even though Selênê is gazing on him.

Telescope (Gr. τῆλε, *afar off*, and σκοπέω, *I look at*). An optical instrument for viewing distant objects.

For several reasons a distant object is seen less distinctly than a similar near one. The angle which an object subtends diminishes as the distance increases; the density of light which renders it visible also diminishes with the distance, but in a much faster ratio; and a considerable portion of light is always lost in its passage through the atmosphere.

It is found by experience that to be discernible at all in ordinary daylight, a detached object must subtend at the eye an angle of not less than 30″, and that the least angle under which contiguous objects can be satisfactorily distinguished is about one minute. By the aid of a telescope, a magnified image of the object is obtained; and within certain limits the object is not only apparently enlarged, but rendered brighter than it appears to the unassisted eye.

The invention of the telescope, to which practical astronomy is indebted for its most important discoveries, has been ascribed to various persons. Sir David Brewster (*Ency. Brit.* art. 'Optics') says: 'We have no doubt that this invaluable instrument was invented by Roger Bacon or Baptista Porta, in the form of an experiment; though it had not, perhaps, in their hands assumed the maturity of an instrument made for sale, and applied to useful purposes, both terrestrial and celestial. If a telescope is an instrument by means of which things at a distance can be seen better than by the naked eye, then Baptista Porta's concave lens was a real telescope; but if we give the name to a tube having a convex object-glass at one end, and a convex or concave lens at the other, placed at the distance of the sum or difference of their focal lengths, then we have no distinct evidence that such an instrument was used before the beginning of the seventeenth century.' Descartes ascribes the invention to James Metius, a citizen of Alkmaer in Holland; Huygens to John Lippersey, or Zacharias Jansen; Borellus also to Jansen. Professor Moll, who has discussed these rival claims, after examining the official papers preserved in the archives at the Hague, comes to the conclusion that Metius (whose proper name was Jacob Adriansy) was, on the 17th of October, 1608, in possession of the art of making telescopes; but that from some unexplained reason he concealed his invention, and thus gave up every claim to the honour which he would have derived from it; that on the 21st of October in the same year, 1608, John or Hans Lippersey, a spectacle-maker of Middleburg, was actually in possession of the invention; and that there is little reason to believe that either Hans or Zacharias Zanz (or Jansen, father and son) were inventors of the telescope, though one of them invented a compound microscope about 1590. (*Journal of the Royal Institution*, vol. i.)

The telescope soon made its way into other countries. In April or May, 1609, the illustrious Galileo, having heard a rumour of the invention, set about considering the means whereby distant objects could be seen distinctly, and was soon in possession of a telescope which magnified three times. In subsequent trials he succeeded in increasing the magnifying power; and before the beginning of 1610, he had observed the satellites of Jupiter. Our countryman Harriot also, in 1609, began to use the telescope for examining the disc of the moon, and before he had heard of the discoveries of Galileo. (Priestley's *History of Discoveries relating to Vision, Light, and Colours.*)

Telescopes are of two kinds, *refracting* and *reflecting*: the former depending on the use of properly figured lenses, through which the rays of light pass; and the latter on the use of specula, or polished metallic mirrors, which reflect the rays; an inverted image of the object being formed in both cases in the focus of the lens or mirror.

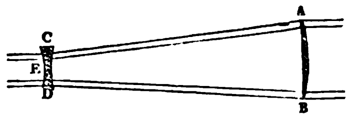
Refracting telescopes were those which were first constructed. They were of the most simple character, consisting merely of an object-glass of one lens, and an eye-glass of one lens,

but of a shorter focus. The action of a prism on a ray of light is familiar to all. It refracts it and sends it out of its course. A lens may be looked upon as an infinite series of prisms arranged symmetrically round an axis, and hence parallel rays falling on a lens are bent to a point called its *focus*. Such a lens we have in our eye, and at its focus lies the retina, on which a picture is painted. Now, a telescope is an extension of the principles on which our eye is constructed. In the eye a lens forms an image and we see; in the telescope one lens, called the *object-glass*, forms an image, and another lens, called the *eye-piece*, gathers up the rays from each part of the image, and transmits a parallel beam from each point to the eye. If only single lenses be used, the prismatic colours produced by the difference of refrangibility of the luminous rays tinge the images of all objects seen through the telescope, and the image is likewise distorted by the aberration of the extreme rays. It was soon found that the latter defects could be sufficiently corrected by employing more lenses than one in the eye-piece; but it was long before a remedy was found for the chromatic dispersion; and artists, despairing of success, generally turned their attention to the improvement of instruments of the reflecting class. The difficulty, however, was at length overcome through the persevering efforts of John Dollond [ACHROMATISM; OBJECT-GLASS]; and the *achromatic refracting telescope* may now be regarded as an instrument all but perfect.

The principles on which the action of telescopes depends having been explained under the terms REFLEXION and REFRACTION, and the properties and construction of their principal parts under ACHROMATISM, EYE-PIECE, LENS, MIRROR, and OBJECT-GLASS, we shall here describe some of the principal forms which the instrument has assumed. It will be borne in mind that the general aim in the construction of a telescope is to form, by means of lenses or mirrors, as large, bright, and distinct an image of a distant object as possible, and then to view the image with a magnifying glass in any convenient manner. Now, the brightness of the image depends upon the quantity of light. Thus, in the case of ordinary eyesight we use a beam of light about one-fifth of an inch (the aperture of the pupil) in diameter. As many times as the surface of an object-glass or speculum exceeds the surface of the pupil, by so many times is the light increased. The *distinctness* depends upon the purity of the material (in the case of the object-glass) and the correctness with which the rays are made to converge to a point. We will begin our notice of the various kinds of telescopes by describing those of the refracting class.

Galilean Telescope.—This is the most ancient form of the telescope, and is that which was used by Galileo. It consists of a convex converging object-glass, A B (fig. 1), and a concave diverging eye-glass C D. On passing through the object-glass A B, the rays of light coming from the different points of a distant object in sensibly parallel pencils are rendered convergent, and proceed towards the principal focus, where they would form an inverted image; but before

Fig. 1.

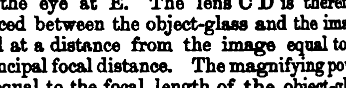


they arrive at this point they fall upon the concave lens C D, by which they are again rendered parallel, or at least their convergence is corrected so as to give distinct vision of the object to the eye at E. The lens C D is therefore placed between the object-glass and the image, and at a distance from the image equal to its principal focal distance. The magnifying power is equal to the focal length of the object-glass divided by the focal length of the eye-glass. [LENS.]

In this telescope the object is seen erect, and the length of the tube is only the difference between the focal lengths of the two lenses. These properties render it preferable to any other telescope for many ordinary purposes; as, for example, an *opera-glass*. When used for this purpose, the magnifying power is hardly ever greater than 4; and it is often as low as 2.

Astronomical Telescope.—This is composed (fig. 2) of a converging object-glass A B, and of a converging eye-glass C D. Rays of light proceeding from any point M of a distant object M N, and falling on the whole surface of the object-glass, are refracted into a point *m* in the

Fig. 2.



principal focus. In like manner, those proceeding from the point N are refracted into the point *n*: and thus an inverted image *m n* is formed at the focus of the object-glass. The eye-glass is placed so that its focus shall coincide with the place of the image: consequently rays diverging from any point of the image, and falling on the lens C D, are rendered parallel and enter the eye at E, and are thereby rendered fit to produce distinct vision. The length of the telescope is equal to the sum of the focal distances of the two lenses; and the magnifying power is equal to the focal length of the object-glass divided by the focal length of the eye-glass. This telescope was first described by Kepler in his *Dioptrice* (1611); but it does not appear to have been executed until about twenty or thirty years later.

Great strides have recently been made in the construction of the refracting astronomical telescope. At the present time (Jan. 1867), the largest of its class is being finished by the

eminent English opticians, Messrs. Cooke and Sons, of York. Its object-glass is of the enormous size of twenty-five inches in diameter. Mr. Alvan Clark, of America, has also recently constructed one of eighteen and a half inches. Till within the last few years almost all the most celebrated telescopes were constructed in Germany; and to give some idea of one of the finest existing instruments, we may describe the one in use at the observatory of Pulkowa. Its object-glass has a clear aperture of very nearly 15 inches, and its focal length is 22·5 feet. The length of the part of the tube between the object-glass and the declination axis is 13·7 feet, and that of the part between the eye-piece and the declination axis is 9·2 feet. The tube is of wood; it is of a conical shape, and the exterior diameters at the extremities are 17·0 inches and 11·8 inches. The telescope is furnished with six eye-pieces, whose powers vary from 152 to 1,218, and with other eye-pieces, twenty-one in number, belonging to the micrometrical apparatus with powers as high as 2,000.

The mounting is that known by the name of the *Fraunhofer mounting*, having the telescope on one side of the polar axis. The polar axis is nearly 4 feet in length, and the diameter of the horary circle is 18 inches, and is divided to 40″ of time. Sidereal motion is given to the telescope by clockwork.

The instrument was constructed by Messrs. Merz and Mahler, of Munich, and is in most respects similar to that erected at Cambridge, Massachusetts, near Boston, U.S., of which we also append a description.

The *Cambridge* telescope belongs to the observatory in connection with the Harvard university. It has not been erected many years, but it has already earned considerable fame by the discovery of some comets, of the crape ring and eighth satellite of Saturn, and by micrometrical observations (of great excellence and importance) of nebulæ.

The telescope and its equatorial mounting are the work of Messrs. Merz and Mahler. The extreme diameter of the object-glass is 15½ English inches, the effective aperture barely 15 inches, and the focal length 22 ft. 6 in. The mounting, like that of the preceding telescope, is that known as Fraunhofer's, i. e. the telescope is not in the plane of the polar axis, but on one side of it, supported near its centre at one extremity of the declination axis, and counterpoised by a weight beyond the other extremity of the declination axis. The declination circle is 26 inches in diameter, and is read by four verniers to 4″ of arc; the hour circle is 18 inches in diameter, and is read by verniers to single seconds of time.

Sidereal motion is communicated to the telescope by clockwork, regulated by the friction of centrifugal balls.

It is furnished with nine eye-pieces, whose powers vary from 103 to 1,118, and with a wire-micrometer eye-piece and position circle. The screw of the micrometer has been severely tested, and found to be of sensibly equal value throughout its length.

The whole aperture can be used without injury to the definition, and the discs of stars are remarkably small. In measuring double stars, powers from 700 to 1,200 have been habitually employed. On rare occasions, a power of 2,000 has shown well the discs of Neptune and of the satellites of Jupiter.

With powers of 700 and 800, stars have been separated whose measured distance has proved to be 0·3″. The satellites of Neptune and the inner and eighth satellite of Saturn are seen steadily, as well as the edge of the ring at what is called its disappearance. (*Description of the Observatory at Cambridge, Massachusetts*, by William Crouch Bond.)

The next telescope which we propose to describe is that called the *Northumberland telescope*, at the observatory connected with our own university at Cambridge. It may be taken as a specimen of what is termed the *English mounting*. The object-glass, by Cauchoix of Paris, is of 11½ inches effective aperture, and the focal length is 19½ feet. The telescope is in the plane of the polar axis, which is here represented by a series of supports parallel to it and supported at top and bottom. The hour circle is 5½ feet in diameter, and is not permanently attached to the polar axis, but can be clamped to or released from the lower iron frame at pleasure. There is no declination circle, but its place is supplied by a declination sector, i. e. a graduated arc carried by a flat brass bar nearly 6 feet in length, turning about a pin fixed in the telescope tube at the distance of rather more than 2½ feet from the axis of revolution of the telescope. This serves to measure small differences of declination. The instrument is provided with clockwork. The whole of the mounting was constructed under the direction of the Astronomer Royal, Mr. Airy. (*Cambridge Observations*; Airy's *Description*; Weale's *London Exhibited in* 1851.)

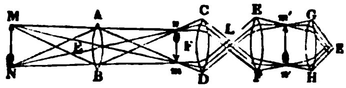
We give an illustration of the *Cooke mounting* (fig. 4), which is German in principle, though the details vary extremely from that construction of instrument. Telescopes of this kind, being generally used with a high magnifying power, and consequently having a small field of view, are always accompanied with a small telescope, or *finder*, fixed to the tube, so that the axes of the two instruments are exactly parallel.

Terrestrial Refracting Telescope.—This differs from the astronomical telescope only in having two additional lenses E F, G H (fig. 3), placed in the tube of the eye-glass for the purpose of restoring the inverted image to its erect position, and thereby accommodating the telescope to terrestrial objects. The focal lengths of these additional lenses are usually the same as that of the eye-glass. The two pencils of rays proceeding from the points M and N cross each other in the anterior focus of the second lens E F, and falling parallel on E F form in its principal focus an inverted image of *m n*, and consequently an erect image

of the object M N. This image $m' n'$ is seen by the eye at E through the lens G H, as the rays diverging from m' and n' in the focus of G H enter the eye in parallel pencils. When the first three lenses are equal, the magnifying power is the same as that of the astronomical telescope, whose object and eye glasses are the same as A B and C D.

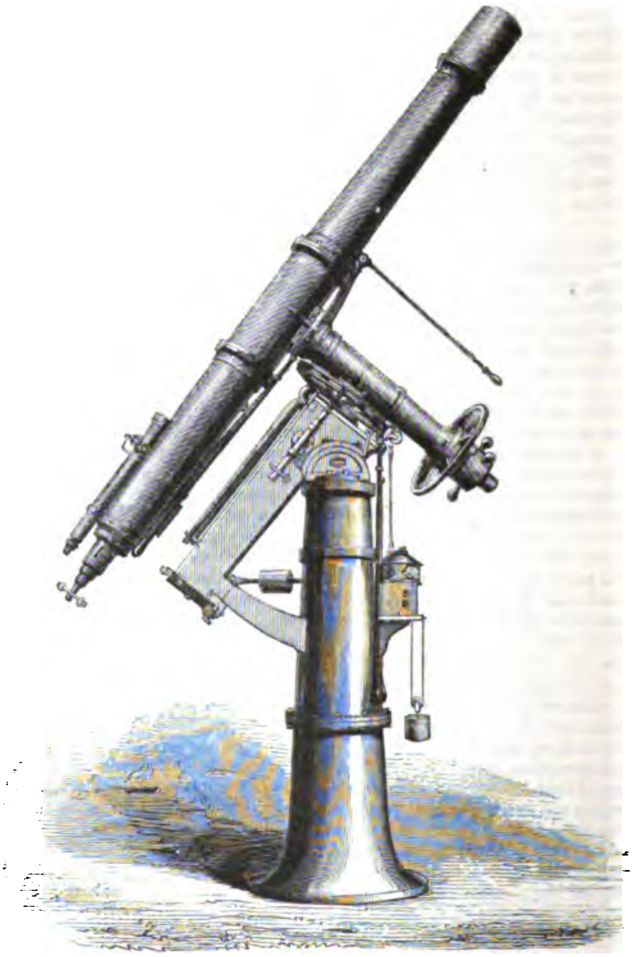
The performance of refracting telescopes depends most essentially on the perfection of the object-glass; for if the first image is bright and distinct, and perfectly achromatic, there is little difficulty in constructing eye-pieces to

Fig. 3.



magnify it, without causing it to undergo any sensible alteration.

Fig. 4.

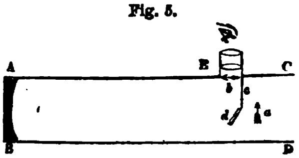


Reflecting Telescopes.—In reflecting telescopes, the speculum, or mirror, performs the office of the object-glass in those of the refracting kind, and is therefore called the *object-mirror*. The instrument is constructed in various forms; but these differ from one another chiefly in reference to the contrivances which have been adopted for bringing the focal image into a convenient situation for being viewed by the eye-piece. The principal forms are the Newtonian, the Gregorian, the Cassegrainian, and the Herschelian.

Newtonian Telescope.—Let A B C D (fig. 5) represent a section of the tube of the telescope: A B a section of the object-mirror, which would form at its focus the image a of any distant

object. Now, if a person attempted to view the image in its place at *a* by placing himself directly before the mirror, he would necessarily intercept the rays of light from the object

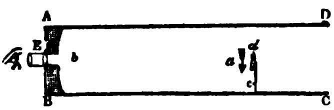
Fig. 5.



passing down the tube to the mirror, and consequently there would be no image to view. Sir Isaac Newton overcame this difficulty by introducing a small diagonal plane speculum *d* between A B and *a*, which, itself intercepting but a small portion of the light, reflects towards the side of the tube the rays converging from A B, and causes the image which would have been formed at *a* to be formed at *b*, where it can be conveniently viewed by the eye-piece E attached to the side of the tube. The small mirror is of an oval form, and is fixed on a slender arm *c* connected with a slide, by means of which it may be made to approach or recede from the large speculum A B, as the image approaches to or recedes from it. In this telescope the magnifying power is equal to the focal length of the object-mirror A B divided by that of the eye-glass.

Gregorian Telescope.—In this construction the object-mirror A B (fig. 6) is perforated in the middle, and the rays of light from a distant object being reflected from the surface of A B cross each other in the focus, where they form an inverted image *a*, and are then intercepted by a small concave mirror *d*, which causes them again to converge to a focus at *b*, near the perforation of the object-mirror, where they form a reinverted or direct image, which is viewed by an eye-piece E screwed into the tube behind A B. The curvature of the small speculum should be elliptical, having the foci at *a* and *b*; but it is generally made spherical. In this case the great speculum should be slightly hyperbolic, to counteract the aberration of the small mirror.

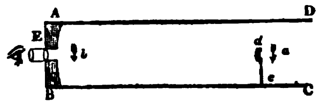
Fig. 6.



Cassegrainian Telescope.—The great speculum of this instrument is perforated like the Gregorian; but the rays converging from the surface of the mirror A B (fig. 7) towards the focus *a* are intercepted before they reach that point by a small convex mirror *d*, not sufficiently convex to make the rays divergent, but of such a curvature as to prevent them from coming to a focus till they are thrown back to *b*, near the aperture in A B, where they form an inverted image which is viewed by the eye-piece E. This construction has the advantage of requiring a shorter tube than the Gregorian; but the inversion of the image is not corrected, and for this reason probably it has not been much used.

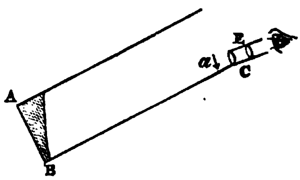
In the two last constructions the small mirror *d* is adjusted by means of a rod turning on a shoulder near the eye end of the tube, and connected by a screw with the apparatus which carries the arm *c* to which the mirror is attached.

Fig. 7.



Herschelian or Front-view Telescope.—This construction differs from the others in having no second mirror, and thus preventing loss of light by a second reflexion. The large speculum A B (fig. 8) is placed at the bottom of the tube in an inclined position, so as to bring the focal image *a* near the edge of the tube, where it is viewed directly by the eye-piece E without interfering much with the light entering the telescope from the object observed, but the image is a little injured by the oblique reflexion. The magnifying power is the same as in the Newtonian.

Fig. 8.



The reflecting telescope was invented by James Gregory, and is described by him in his *Optica Promota* (1663); but the first telescope of the kind was executed by Newton. The celebrated instrument of Sir William Herschel, erected at Slough in 1789, was 40 feet in length. Its great speculum had a diameter of 49½ inches; its thickness was about 3½ inches, and its weight when cast was 2,118 lbs. Its focal length was 40 feet, and it admitted of a power of 6,450 being applied to it. The essential advantage of large telescopes of this kind consists in the immense quantity of light which they collect, thus enabling the observer to perceive faint nebulæ and stars which are altogether invisible in ordinary instruments. For the more accurate kinds of work they are inferior to refractors, as it is almost impossible to obtain a perfect figure.

Reflecting telescopes are used only for observing *phenomena*. In order to derive full benefit from them, they must be used in the open air, and must either be mounted equatorially [EQUATORIAL] or else in such a manner

as to be capable of a smooth motion both in a vertical and horizontal direction.

Lord Rosse's 50-ft. Reflecting Telescope.—This enormous telescope, which has two mirrors of 6 ft. diameter, and is 53 feet in focal length, was begun in 1842. The metal used for the specula is an alloy of tin and copper in atomic proportions, the weight of the copper being something more than double that of the tin. The weight of metal in one of the specula is $3\frac{1}{2}$ tons, and that of the other 4 tons. For fusing these immense masses of metal it was placed in three iron crucibles cast expressly for the purpose, each crucible weighing of itself about $1\frac{1}{4}$ ton. The crucibles were placed in as many furnaces, whose mouths were level with the ground, and with flues opening into one common stack or chimney. The metal for its complete fusion required to be kept in the furnace about twelve hours, and when it was in the state proper for casting, the crucibles were withdrawn from the furnaces by means of a powerful crane to the iron cradles or pouring frames arranged round the mould at intervals of ninety degrees.

The mould had for its base a framework of hoop iron six inches in depth, placed edgewise, packed in a strong frame, and supported by strong transverse bars beneath. The upper edges of these were ground into a slightly convex surface of about 108 feet radius, and thus formed the base of the mould; allowing the air to escape through the interstices, though, from its viscosity, no particle of the alloy could escape through them. The metal also by being poured upon the iron became chilled immediately into a dense sheet of about half an inch thick, and thus secured one of the conditions which have been found to be most important, if not indispensable, in the casting of speculum metal. After becoming tolerably solid, the speculum was withdrawn to the annealing furnaces, where it remained for about sixteen weeks, when it was considered to be ready for the process of grinding and polishing.

A full account, given by Lord Rosse, of the polishing machinery will be found in the *Phil. Trans.* for 1840 and for 1861. It is sufficient to state that the beam carrying the polisher is moved by a small steam engine, by which a rotatory motion round a vertical spindle is given to a crank, which by a connecting rod acts upon a sliding rod which moves the grinder or polisher backwards and forwards. By such means the polisher makes strokes backwards and forwards very nearly in the manner in which the hand would make them, if the polishing were performed by hand, and at the same time another part of the machinery causes the frame carrying the speculum, and therefore the speculum itself, to revolve with a slow motion. We must remark further, in connection with this part of the subject, that it was necessary to cast and polish the speculum upon the same fixed frame (distinct from the rotatory frame before mentioned) that would support it when in the telescope. For this purpose the fixed frames are provided with small wheels, by which, after being conveyed in a carriage to a railroad running into the lower part of the tube of the telescope, the speculum is deposited in its proper position for use.

For the support of the mirror in such a way as to avoid strain and flexure, a very ingenious system of levers is employed. This consists of a combination of three similar systems, resting on three points under the centres of gravity of the three equal sectors into which the speculum may be supposed to be divided. Each system consists of one triangle with its point of support directly under its centre of gravity, upon which it freely oscillates. This triangle carries at its angles three similar points of support for three other triangles, under their centres of gravity, and they again at their angles carry in a similar way cast-iron platforms formed of three ribs, so as to make a kind of irregular open-work grating, supported under their centres of gravity. There are thus twenty-seven platforms, which are coated with greased cloth, and upon these the speculum is supported, each bearing $\frac{1}{27}$ of the weight.

The above is the construction first adopted by Lord Rosse. But, as the surface of the speculum by the pressure on its edge at different elevations was found to be distorted, instead of the platforms in contact with the back before mentioned there were adopted eighty-one brass balls capable of revolving freely, i. e. three at the corners of each triangle, occupying the place of the platform in the former construction.

We now come to the mounting of this immense speculum. The tube of the telescope is made of wood, and is at the middle about 7 ft. in diameter; the interior exceeding 6 ft. in every part. This is fixed to a cube of 10 feet, which has folding doors in one of its sides for admission of the speculum, and which carries the fixed frame supporting the mirror on the side opposite to the mouth of the telescope. To this side of the cube is attached a universal joint by which the lower end of the telescope is connected with a fixed support, the joint being a few feet below the general surface of the ground.

On the east and west sides of the telescope are immense piers about 70 feet long and nearly 50 feet high, of which the eastern carries a large iron arc of a circle, in which moves a slider attached to a racked bar working by means of a pinion carried by the telescope tube, while the other carries the stairs and galleries necessary for the observers. Near the tops of the piers in the east and west plane passing through the universal joint are two cranes with pulleys, over which pass chains attached to the telescope. To the ends of these chains, after they have passed through fixed pulleys in the walls, are attached counterpoises, weighing about four tons each. There is also a contrivance connected with the chains for equalising the action of the counterpoise-weights in different positions of the telescope.

By means of a rack and pinion, the observer, standing near the eye-end of the tube, is enabled to give a motion in hour angle of about half an hour on each side of the meridian position.

At the south end of the piers there are strong ladders, and upon these (assisted by counterpoises) there slides a stage upon which a small observing gallery travels backwards and forwards. For great elevations, curved galleries are mounted upon the curved slope of the upper part of the western pier, carried by beams running above and below pulleys fixed to the top of the pier; they are run out by rack-and-pinion work to approach the side of the telescope.

A quick motion in declination is given by the windlass below, and a slow motion is given by hand above for measurements: the quick motion in right ascension is given also below by a wheel turned by a workman, and the slow motion by hand above.

The tube is slung by chains, and is perfectly steady in a gale of wind. It carries at the upper extremity the apparatus for the Newtonian small mirror, which is itself of considerable size and weight, the minor axis of its ellipse being about 6 inches; but Lord Rosse has made provision in the construction of his observing galleries for using it as a Herschelian telescope, if it is found necessary or desirable to obtain an increase of light.

In the use of this wonderful instrument, Lord Rosse has hitherto confined himself chiefly to the observations of nebulæ.

Reflecting Telescopes with silvered Glass Specula.—Recently, Steinheil of Munich and Foucault of Paris have successfully constructed specula of glass which, after polishing and figuring, receive a film of pure silver, deposited by chemical means upon their figured surfaces. This film does not exceed $\frac{1}{12,000,000}$ of an inch in thickness, but according to Steinheil it reflects, when polished with rouge, 90 per cent. of the light falling upon it, whilst speculum metal reflects only about 63 per cent. Another advantage connected with glass specula is that a good figure when once produced is permanent, since it is not altered either by the deposition or subsequent polishing of the silver film, whereas the figure of a metallic speculum is liable to serious alteration at every polishing. Thus there is every encouragement to bestow great labour upon the figuring of a glass speculum. Several small telescopes upon this principle have been constructed in this country. One of them, of 7 inches aperture, and with a power of 270, divides with ease and certainty the very close double star η Coronæ.

Eye-pieces of Telescopes.—When the image formed by the object-glass or mirror is viewed with a single lens or eye-glass, whether concave or convex, it is only in the centre of the field that distinct vision is obtained, all towards the margin being hazy and distorted. To remedy this defect, Boscovich and Huygens independently proposed the construction of an eye-piece formed of two lenses, placed at a distance from each other equal to half their focal length. Boscovich recommended two similar lenses: Huygens, that the focal length of the one should be twice that of the other: and as this construction is found to answer best in practice, it is that which is most commonly used.

The two lenses are usually plano-convex, with the convex faces towards the object-glass; the larger lens, called the *field-glass*, is innermost, or nearest the object-glass: and a diaphragm cutting off the marginal rays is usually placed between them near the focus of the eye-lens, where the image is formed. This eye-piece is usually called the *negative* eye-piece, from its having the image seen by the eye behind the field-glass; and is that which is commonly supplied with telescopes intended only for the purpose of *seeing* objects, without reference to measurement.

Another modification of the two-lens eye-piece was proposed by Ramsden, and is called the *positive* eye-piece, because the image observed is before both lenses. The lenses are plano-convex, and nearly of the same focal length; but their distance from each other is less than the focal distance of the lens nearest the eye, two lenses thus placed acting as a compound simple lens. This eye-piece is the most convenient when micrometer wires are placed in the focus, because it can be taken out without injuring the wires; and it has also this advantage, that the measure of an object given by one eye-piece is not altered when it is changed for another of a different magnifying power.

In both the eye-pieces now described, the image is seen inverted; and though this is of no importance in astronomical observations, it is inconvenient when the telescope is used for looking at terrestrial objects. By placing an additional pair of lenses in the tube of the eye-piece, the image is repeated and reinverted, and consequently seen erect. By this means, as explained above, the terrestrial telescope is obtained.

The name of *diagonal eye-piece* has been given to eye-pieces furnished with a diagonal reflecting mirror, the object of which is to give a more convenient direction to the rays emerging from the eye-piece when the telescope is pointed high. [Eye-piece.]

Telescopes are generally supplied with eye-pieces of different powers, which are all fitted to enter the same tube: and the focal adjustment is commonly effected by a rack-and-pinion motion acting on the tube which carries the eye-piece.

For full information respecting the construction of telescopes, and the best modes of mounting them, to secure steadiness and allow of the requisite motion, the reader is referred to Pearson's *Practical Astronomy*, vol. ii. [Alt-azimuth; Eye-piece; Object-glass; Transit Instrument.]

Tell-tale. On Shipboard, the dial plate at the wheel, showing the position of the tiller.

Teller of the Exchequer. A very lucrative sinecure office, abolished by stat. 4 & 5 Wm. IV. c. 15. In 1780, the emoluments of each teller for the exchequer, exceeded 7,000*l.* a year, and the offices became still more valuable in subsequent years.

Tellina (Gr. τελλίνη, *a species of muscle*). A genus of cockles (Cardiaceous Bivalves in the Cuvierian system), characterised by the hinge of the shell having one tooth on the left and two teeth on the right valve, often bifid; in the right valve there is a plate which does not enter a cavity in the opposite valve. There is a slight fold near the posterior extremity of both valves which renders them unequal at that part, where they gape a little. The soft parts, or animal of the *Tellina*, called *peronæa* by Poli, has two long tubes for respiration and excretion, which can be withdrawn into the shell, and are concealed in a fold of the mantle.

Cuvier separated from the Linnæan *Tellinæ* the genus *Loripes*, distinguished by the feebly developed cardinal teeth, and by a long cylindrical foot. Other genera have since been detached from the Cuvierian *Tellinæ*, which now form a family, *Tellinidæ*, in the system of Lamarck.

Tellurbismuth. A native telluride of lead and bismuth, found only at Field's mine in Georgia, and at the Tellurium mine, Virginia, U.S.

Tellurism (Lat. tellus, *the earth*). A name given to the system of magnetism put forth by Kieser, who substituted the idea of a telluric spirit in place of the universal fluid of Mesmer and the nervous atmosphere of Kluge. This tellurism was not confined to the substance of the earth, but extended to other bodies also. Thus, the moon was said to magnetise the inhabitants of the earth by night, while the sun demagnetised them in the morning. [MAGNETISM, ANIMAL; SOMNAMBULISM.]

Tellurite or **Telluric Ochre.** Native oxide of tellurium. It occurs in small spherical masses with a fibrous radiated structure, at Facebay and Zalathna in Transylvania.

Tellurium (Lat. tellus). This rare metal has only been found in small quantities in the gold mines of Transylvania: it occurs in the metallic state, combined with gold or silver. It is white, brilliant, brittle, and easily fusible. Its specific gravity is about 6·25. It is combustible, and exhales a peculiar odour, like horse-radish, which Berzelius ascribes to the presence of minute portions of selenium. Its atomic weight is 64. It forms a series of compounds resembling those of sulphur and selenium, as hydrotelluric acid HTe, anhydrous tellurous acid TeO_2, hydrated tellurous acid HO,TeO_2, anhydrous telluric acid TeO_3, hydrated telluric acid HO,TeO_3, a chloride and bichloride TeCl and $TeCl_2$, and also a bisulphide TeS_2 and a tersulphide TeS_3.

Tellurium Glance. [NAGYAGITE.]

Telphusa (Gr. Τελφοῦσσα). In Greek Mythology, a daughter of Ladon, who gave her name to a fountain near Haliartos. But in the so-called Homeric hymn to Apollo, she appears rather as the fountain itself than as the nymph of the fountain. In that hymn Apollo is represented as exciting her anger by marking out a place for a temple to be built to himself, and laying its foundations: and Telphusa, to avert the danger threatening her waters, advises him to go on to Crisa, where he slew the dragon Python who nursed Typhaon, the child of HERA.

But Apollo, finding that he had been lured into a desolate land, returned full of wrath to Telphusa, and, hurling down great stones, choked the waters of the fountain for ever.

Tempera Painting. [DISTEMPER.]

Temperament (Lat. temperamentum). In Music, the adjustment of the notes in musical instruments whose sounds are fixed, such as organs, pianofortes, &c. The defect to be remedied arises from the single short keys between the two larger ones serving for flats as well as sharps. It is necessary to observe, that in the theory of harmonies the interval of a tone is not always the same; for instance, that lying between the fourth and fifth of the scale contains nine small parts, called *commas*, whereas that between the fifth and sixth of the major scale contains only eight commas. Again, the diatonic semitone contains five commas, and the chromatic semitone three or four, according to the magnitude of the tone. Hence it is that the different situation of these elements with regard to each other causes intervals of the same names to consist of different degrees or elements. To improve them, therefore, musicians *temper* them so as to reduce the whole more to mean distances from each other, necessarily producing a new division of the octave. Pianofortes are generally tuned on what is called *equal temperament*, i.e. there being eleven notes in the octave, an equal value is given to each interval between them representing a semitone. The consequence of this is that although all the intervals, the thirds, fifths, &c., are slightly imperfect, yet they all approach perfection in the same degree; whereas if some of them were made accurate, others must be very far wrong.

TEMPERAMENT. In Physiology, temperament has been defined as that peculiarity of organisation which to a certain extent influences our thoughts and actions. The ancient physicians enumerated four temperaments; viz. the *bilious* or *choleric*, the *phlegmatic*, the *sanguine*, the *melancholic*. To these some have added the *nervous*; and these terms are still in use among medical writers.

Temperance Societies. According to a statement made at the meeting of the 'World's Temperance Convention' at New York in 1853, the first *National Organisation against Alcohol*, i.e. the *American Society for the Promotion of Temperance*, was established in 1826. Societies of persons pledged by mutual agreement to abstain from intoxicating drink were formed about the same time both in Britain and

America, and differences of opinion as to the strictness of the rules to be followed engendered the different designations of *temperance* and *total abstinence* or *teetotalism*. But the movement may first be said to have become popular, on this side of the Atlantic, through the extraordinary exertions of the Irish priest, Father Mathew, one of those rare men to whom the faculty of kindling popular enthusiasm is given in the highest degree, and one who never abused it for ordinary or personal motives. (Maguire's *Life of Father Mathew*.) He began his preachings at Cork, in 1833, and in a very few years had obtained an extraordinary success. In five months, 131,000 persons took the *pledge* of total abstinence which he tendered to them: and when he travelled round the island, these numbers rose to almost fabulous proportions. But the zeal thus kindled had already died out even before the early decease of its excellent originator. The friends of the temperance movement in America appeared to have achieved a greater success when the state of Maine passed, in 1851, a law *for the suppression of tippling shops*, &c. rendering penal the sale of intoxicating drinks. But the 'Maine Law,' though subsequently adopted by some other states and in the British colony of New Brunswick, is said to have become in a few years a dead letter. The more recent effort of the partisans of the cause in this country has been to persuade the legislature to pass a *permissive* enactment, under which the authorities of any district, with the assent of the majority of the people, should be enabled to close the public-houses. The propagation of these views has been carried on chiefly by the *Alliance for the Suppression of Traffic in Intoxicating Liquors*. It was said, about 1850, that 3,000,000 persons had taken the pledge of total abstinence, of whom 50 per cent. were supposed to have broken it. (See *Edinburgh Review*, vol. c., for a history of the movement down to 1854: its history from that time to the present day presents no new features, and calls for no further comment.)

Temperate Zones. In Geography, two of the five zones into which the terrestrial globe is divided. The *north temperate zone* is included between the tropic of Cancer and the arctic circle; and the *south temperate zone* between the topic of Capricorn and the antarctic circle.

Temperature. The amount of heat in a body perceptible to the senses, measurable by a thermometer, and capable of being transferred to another substance. The following tables of various temperatures contain determinations of general interest. The first table gives the fusing points of the most important metals, according to the pyrometric measurements of the different experimenters named at the head of each column; the least reliable numbers being those in the first column. The second table contains the melting points of the more fusible metals, with some remarkable and extreme temperatures, the name of the authority being generally appended. In both tables the degrees are Fahrenheit, those below zero having a minus sign (—) prefixed.

Table I.

		Wedgwood (corrected)	Daniell	Person	Becquerel
		°	°	°	°
Tin	melts	475	441	451	424
Bismuth	„	476	462	512	495
Lead	„	612	610	620	592
Zinc	„	710	773	779	745
Antimony	„	810	—	—	1103
Silver	„	1823	1773	—	1760
Copper	„	2205	1996	—	2235
Gold	„	2518	2016	—	1998
Cast iron	„	2696	2786	—	—
Wrought iron	„	—	—	—	—
Platinum	„	—	—	—	2912

Table II.

Absolute zero	— 460°	(calculated)
Greatest artificial cold	— 220	(Natterer)
Greatest natural cold	— 56	(Sabine)
Mercury melts	— 39	
Snow and salt	— 4	
Bromine melts	9·5	
Ice melts	32	
Blood heat	98	
Phosphorus melts	111·5	(Schrötter)
Potassium „	136	(Regnault)
Yellow wax „	144	(Person)
Fusible alloy „	201	
Sodium „	208	(Regnault)
Water boils	212	
Iodine melts	225	
Sulphur „	239	(Person)
Mercury boils	662	
Dull red heat	1292	(Pouillet)
Cherry „ „	1552	„
Orange „ „	2012	„
White heat	2372	„
Dazzling white	2732	„
Blast furnace	3280	(Daniell)
Voltaic arc	3758	(Becquerel)

Tempering. A term applied to the process by which the hardness of steel is more or less reduced. [Steel; Steel Guns.]

Templars or **Knights of the Temple.** A military religious order. It was founded by an association of knights, in the beginning of the twelfth century, for the protection of pilgrims on the roads in Palestine: afterwards, it took for its chief object the protection of the Holy Sepulchre at Jerusalem against the Saracens. Knights were fixed at Jerusalem by King Baldwin II., who gave them the ground on the east of the Temple. Their rules, taken from those of the Benedictine monks, involved the vows of chastity, obedience, and poverty. The classes of the order were, knights, esquires, servitors, and chaplains; the universal badge of

the order was a girdle of linen thread. The officers of the order were chosen by the chapter from among the knights; they were, for military affairs, marshals and bannerets; for purposes of government, priors, who superintended single priories or preceptories; abbots, commanders, and grand priors, who governed the possessions of the order within separate provinces; and the grand master, who, in some respects, assumed the dignity of a sovereign prince, being independent in secular matters, and depending solely on the pope in spiritual. The chief part of the 9,000 estates, lordships, &c., which the society possessed in the thirteenth century, was situated in France; and the grand master was usually of that nation. The Templars, with the rest of the Christians, were driven from Palestine by the Saracens, and then fixed the chief seat of their order in Cyprus. Their exorbitant power and wealth, and the haughty manner in which they endeavoured to keep aloof from the control of European sovereigns and act as a military republic independent of their authority, were probably the principal reasons which induced Pope Clement V. and Philip the Fair of France to concert their overthrow. The charges of heresy and idolatry, which were preferred against them, were at least unsupported by evidence. In 1307, Jacques de Molay, the grand master, having been enticed into France, was arrested by Philip; the estates of the order were seized; many of the Templars were burnt alive, after the mockery of a trial; and, in 1312, the order was abolished by a bull of Clement V. Its vast estates fell partly into the hands of the sovereigns of the countries in which they were situated, partly into those of the Hospitallers and other military orders. Detached bodies of the order, however, continued to subsist for some time in different countries. See, among numerous authorities, Raynouard's tragedy of *Les Templiers*, with the notes; Turner's *England in the Middle Ages*, vol. ii.; *Mém. de l'Acad. des Inscr.* vol. xxxvii.; Addison's *History of the Knights Templars and the Temple Church*, 1842; Milman, *History of Latin Christianity*, book xii. For a notice of the strange irreligious doctrines attributed to them, see the article BAPHOMET.

Temple (Lat.). Like the Greek τέμενος (from τέμνω, *to cut*), this word meant originally any piece or portion cut off from a whole; and the limitation of the name to buildings is of comparatively late date. Thus Livy (i. 6), using the word in the sense of an open space, speaks of Romulus and Remus as taking temples for the purposes of augury on the Palatine and Aventine Hills; and by Lucretius and Cicero the term is applied to the expanse of the heavens, or to the space in which the globe of the earth moves. In a religious sense, the word denotes properly a sacred enclosure, which may or may not contain buildings, this enclosure having reference to the portion of sky within which the omens were to be observed by the augurs. Those places only which had thus obtained the sanction of the gods were strictly temples; edifices consecrated only by man, as by the pontiffs, were called *sacella* or chapels, and thus the sanctuary of Vesta was only an *ædes sacra*, not a *templum*. By the Latins the ground lying beyond this enclosure was regarded as profane; by the Greeks it was termed βέβηλος, as being ground on which everyone might walk. Within the enclosure, as a rule, no dead might be buried, and this rule was extended to the whole of the sacred island of Delos [ORTYGIA], which was regarded as the τέμενος or sacred portion of PHŒBUS.

The earlier Greek temples were made chiefly of wood, and were at first little more than hollowed trunks of trees in which some image or symbol of a god was inserted. The form of the later temples was oblong, and they were generally surrounded with pillars, the parallelogram being divided into two parts, the πρόναος, or vestibule, and the cella, or ναός, the proper habitation of the god, to which was added in temples of the largest class the OPISTHODOMUS, which commonly served as a treasure chamber. The small size of the abodes in which the images of the gods were placed characterised all temples, and especially marked those of Egypt. Most of the temples still remaining in Attica, Ionia, and Sicily, have their entrances to the east, although it is stated by Vitruvius that Greek temples always faced the west. For the images of the gods placed in these buildings, see SCULPTURE.

Vitruvius classified quadrangular temples as temples: 1. IN ANTIS; 2. PROSTYLE; 3. AMPHIPROSTYLE; 4. PERIPTERAL; 5. DIPTERAL; 6. PSEUDODIPTERAL; and 7. HYPÆTHRAL. But it is not easy to determine in all cases whether a temple was hypæthral or not, and this is especially doubtful in the case of the Parthenon on the Athenian ACROPOLIS. Among other celebrated temples were those of Zeus at Olympia, of Artemis at Ephesus, of Apollo at Delphi, of Aphroditê at Paphos, and of the Capitoline Jupiter at Rome. A circular form for temples was adopted in some instances, but not in the earlier times, the oldest examples of round buildings being probably mere *tholi*, or monumental edifices. Among circular temples, those of Vesta at Tivoli and the Pantheon at Rome, still used as a church, are the best known.

In many, perhaps originally in all, nations, the first objects set up, whether for veneration or merely as symbols, seem to have been conical figures, sometimes in the form of single stones, sometimes in the shape of heaps or mounds. Thus, Jacob is represented as setting up a stone before he goes to rest in the evening. That these stones were in many cases symbols of the reproductive power of nature, is admitted on all hands; and the same figure was seen in the Ashera set up in the temple at Jerusalem [PHALLUS], and in the Brahmanic LINGAS, with which the ROUND TOWERS of Ireland, and other edifices of a like character, are by some connected.

The plan of the temple of Jerusalem, specially known as the temple of Solomon, is, like the plan given in the descriptions of the tabernacle, not unlike that of Greek temples, the cella being represented by the Holy of Holies. The temple of Solomon, built in great part by Phœnician workmen, sent by Hiram, king of Tyre, was destroyed by Nebuchadnezzar. The temple which succeeded it, after the return of the Jews from Babylon in the time of Cyrus, continued to the days of Herod the Great, who began repairs which amounted almost to a complete rebuilding. This restoration was scarcely finished when the city was destroyed by Titus. For the controversies on the subsequent history of the buildings contained in the temple area, see SEPULCHRE, CHURCH OF THE HOLY.

Templet or **Template.** In Architecture and Engineering, a short piece of timber, or stone, laid under the bearing of a girder, with the object of distributing the weight of the latter. Also, a mould used by bricklayers, masons, &c. for cutting or setting out work; or by millwrights, for cutting the teeth of wheels. Also, any plate or board formed to the exact dimensions of parts of engines and machines, so that new parts may be produced from such templets of the exact size required to fit the other parts.

TEMPLET. In Artillery, an iron plate, one side of which is made to correspond exactly with the correct exterior of an elongated shot or shell. It is used as a gauge.

Tempo (Ital. *time*). In Music, the Italian word constantly used to express time.

Tempo d'Imbroglio (Ital. *time of trouble*). In Music, a term applied to a composition written in one measure, but really performed in another.

Temporal or Temple Bones. Two irregular bones, one on each side of the head. They are connected with the occipital, parietal, and sphenoid bones, and are articulated with the lower jaw. Comparative anatomy shows that the so-called *temporal bone*, in man, is essentially an assemblage of five bones, called squamosal, zygomatic, tympanic, petrous, and mastoid; having distinct functions developed in different proportions, and continuing permanently detached in the cold-blooded classes, but soon coalescing in the warm-blooded classes. The tympanic element, however, continues permanently detached in birds.

Tenacity of the Metals. The power which metallic wires possess of sustaining, without breaking, the action of a suspended weight. [COHESION; STRENGTH OF MATERIALS.]

Tenaculum (Lat. *a tie*). A surgical instrument, consisting of a fine sharp-pointed hook, by which the mouths of bleeding arteries are seized and drawn out, so that in operations they may be secured by ligatures.

Tenaille (Fr.). In Fortification, a small work placed before the curtain, and intended to secure it and the flanks against being breached, which would render retrenchments in bastions useless. [FORTIFICATION.]

Tenaillon (Fr.). In Fortification, an outwork made on each side of a small ravelin to increase its strength, and to cover the shoulders of the bastion. Works of this kind are, however, so defective that they are not now adopted.

Tenancy in Common. In Law, tenancy in common occurs when property is given or conveyed to two or more persons in undivided shares, each share being distinct in title. In this case there is no right of survivorship as in joint tenancy (which indeed a tenancy in common resembles in the unity of possession only), but each tenant in common is, as to his own undivided share, in the position of the owner of a separate estate. Any tenant in common may compel a partition of the property held in common.

Tenant, Tenement (from Lat. teneo, *I hold*). In Law. These words are derived from the principles of the feudal system, according to which (as it prevailed in England) no land was without a lord; and everyone who enjoyed land *held* it either of a mesne tenant, or of the crown. The party holding the land is called *tenant*; the thing holden, *tenement*; the mode of holding, *tenure*. Thus, tenants are said to be in *fee simple, in tail, for life, for years*, &c. Tenement, in the largest sense of the word, is everything which may be holden; viz. all corporeal hereditaments, and incorporeal hereditaments of a permanent nature issuing out of the same. Thus, lands, houses, rights of common, &c., franchises, dignities, are all tenements in the larger sense. In the more narrow acceptation in which the word is popularly applied, it describes a house with the homestead or immediate appurtenances. [TENURE.]

Tenant Right, &c. The social question involved in the demand for *tenant right* is one which has now agitated Ireland for at least a century. It is the chief cause of that deep-seated disaffection towards political association with England which all admit to be the characteristic feeling of the Irish, and exhibits in the plainest and harshest form the discord which may arise between the owner of the soil and its occupier. The distribution of land in the United Kingdom, by which a few proprietors hold the greater part of the soil, while the cultivator has only a precarious interest on payment of a variable rent, is, it must be remembered, peculiar to this country. [RENT.] As the English and Scotch farmer is generally a considerable capitalist, and the farmers as a class are tolerably united, and, as individuals, very independent, the precarious nature of their holding is more apparent than real. Nominally, the farmer, in the great majority of cases, is a tenant at will; actually, he is a permanent occupier at a variable rent. If he makes improvements, the landlord may, in theory at least, cause him, by raising his rent, to pay interest on the outlay of his own capital. In practice, however, while many improvements are effected

by wealthy landlords, public opinion would, in the vast majority of cases, prevent the landlord from taking so unfair an advantage when the improvement was the work of the tenant. Besides, agriculture is only one, and that a comparatively subordinate, part of the industry of Great Britain, and the influence of landowners is to some extent counterpoised by that of other and equally wealthy classes. Lastly, rents are not raised or depressed by competition, the common practice being to fix the rent, and select the tenant, when vacancies occur.

In Ireland the case is very different. Agriculture, and that of a very rude and imperfect kind, is the general occupation of the people. The farms are very small, the tenants not being much above the condition of ordinary labourers, and, in appearance at least, being possessed of very little capital. Much land in Ireland is possessed by non-resident proprietors, who manage their estates by middlemen or bailiffs; and up to comparatively recent times, the resident proprietors — the picture of Irish society in *Castle Rack-rent* is said to be by no means over-coloured—were proverbially thoughtless, extravagant, and reckless. Rents were fixed by auction, and in the absence of any other occupation, and under the pressure of a redundant population, the competition for holdings raised rents nominally to an extravagant height, cottiers agreeing to pay sums which were far in excess of the value to be obtained from the annual produce of the soil, and, of course, being perpetually in arrears with their landlords. This state of things led to attempted evictions, to the murder of bailiffs and other agrarian outrages, the people invariably siding with the criminal, concealing him, and aiding his escape. Absentee proprietors, unimproving landlords, cottier tenancies, did, and to a great extent do still, characterise a country the peasantry of which, more perhaps than those of any other country, are capable of affection towards their social superiors, while they need the aid of capital for developing the resources of the soil, together with the advantage derived from fixity of tenure, in order to be encouraged in applying such means as they may themselves possess. It may be added, too, that most of the great proprietors are aliens to the Irish in descent, in national sympathies, and in religious belief. The creed professed by the great mass of the Irish people, though not now persecuted, was grievously oppressed, during the seventeenth and eighteenth centuries, the harshest and most cruel wrongs having been inflicted by men of Irish descent who had identified themselves with the political Protestantism of the period. (Goldwin Smith's *Irish History and Irish Character*.)

Much, no doubt, of Irish disaffection is to be traced to the history of land tenure in that island. The first adventurers who settled in Ireland, and indeed the English adventurers for many generations afterwards, found the native Irish in possession of a peculiar land law, called the Brehon. The soil was owned by the sept in common, the chief being appointed by the custom of TANISTRY, and the usufruct of the land being distributed according to the custom of Irish gavelkind. The Norman settlers, and after them the English colonists, down at least to the time of Strafford's regency, attempted in vain to import the English law, with its system of feudal dependence, primogeniture, and entails. The Irish, however, gained on them, and, with the peculiar power said to be possessed by Celtic races, induced their visitors to adopt Irish customs, much to the dissatisfaction of the English government. But successive settlements, the enormous forfeitures created after O'Neil's rebellion, the grants of Cromwell, William III., and subsequently the penal statutes against Roman Catholics, led gradually to the adoption of the English feudal law, and the consequent destruction of those qualified but intelligible rights which the ancient peasantry possessed in the sept or village system of the Brehons. The Irish peasantry are to this day alive to the process by which their ancient interests have been annulled, and are profoundly disaffected at the result.

Gradually (perhaps as a compromise with the peasantry), the right of a tenant in his lease, and his claim for compensation when he had by his own labour or capital effected, independently of the landowner, permanent improvements on his holding, were recognised in Ulster, and have been so often admitted that they are probably legal. Great part of Ulster was granted to the city of London, and it is possible that the corporation was either from choice or necessity a more generous landlord than the other settlers. But the privilege accorded to the Ulster tenant has been persistently claimed by the farmers in the other provinces, as yet unsuccessfully, but with increasing energy. On the other hand, the landowners are disinclined to concede rights which would ultimately reduce them to the position occupied by the possessor of a perpetual fee-farm rent, and transfer the real ownership of the soil to the peasantry.

It cannot be doubted that the claims of the Irish peasantry are directly at variance with that theory of English law, with which we are familiar under the name of the law of real property. It is quite another thing to say that this law is in accordance with public policy, still more to assert that rules which may work well in England are available for the Irish people. The solution of the question is difficult, but it ought not to be impossible. It is quite certain that the Irish land system has produced most of that Irish disaffection which, dangerous as it is at home, is far more dangerous on the American continent.

Tenasserime. [TREMENHEERITE.]

Tench (Fr. tenche, Lat. tinca). The name of a species of Cyprinoid fishes (*Tinca vulgaris*, Cuv.), and the type of a subgenus of that family. It is generally more or less abundant in ornamental waters and ponds, but is seldom found in rivers in this country. It is common in most

of the lakes of the European continent, whence it is supposed to have been imported into England. The tench is remarkable for its tenacity of life; it spawns about the middle of June, at which time the female is attended by two males. Their food consists of the smaller soft-bodied aquatic animals, and vegetable matter. In stocking a pond with tench, the large-sized fish should be selected, and two males to one female should be the proportion of the sexes. [TINCA.]

Tender (Fr. tendre; Lat. tendo, *I stretch* or *hold forth*). In Law, the legal tender of a debt is by the actual production and offer of the sum due, unless the creditor dispense with it by a declaration that he will not accept it. The tender must be of money; and, if beyond the sum of 40*s*., in gold, or in what has been rendered by Act of Parliament equivalent for that purpose, viz. bank of England notes, which are a legal tender for every sum above 5*l*., except at the bank of England or its branches. The tender of a larger sum than that due is sufficient, but the creditor cannot be required to give change.

TENDER. A Naval term for a small vessel appointed to attend upon a larger one, to communicate with the shore, &c. It sails in company, but may be sent on expeditions up rivers, &c. where its patron could not penetrate.

Tendo Achillis (Lat.). The large tendon which passes from the muscles of the calf of the leg to the heel. Its name has reference to the fable of the dipping of Achilles in the Styx; his mother, Thetis, having, as it is said, held him by that part.

Tendril (Fr. tendron). In Botany, any slender twining or clasping part or organ by which a plant attaches itself to some other object. It is often a transformation of a leaf which has no lamina, or of which the midrib, elongated beyond it, retains its usual tapering figure, and becomes long and twisted spirally. In the vine it is an abortive bunch of flowers; in the passion flower, a metamorphosed branch. The leafstalk sometimes serves the purpose of a tendril, as in the *Tropaeolum*.

Tenesmus (Gr. τείνω, *I stretch*). An inclination and ineffectual straining to void the contents of the bowels.

Tennantite. A sulphide of copper, arsenic, and iron; named after Smithson Tennant. It occurs in lead-grey crystals at Carn Brea, Dolcoath, Cook's Kitchen, Tincroft, and other Cornish mines; also at Skeelteren, in Norway, and in Algeria.

Tenné, Tawney, or **Brusk.** In Heraldry, a colour or tincture, represented in blazonry by crossing lines horizontal and diagonal from left to right downwards. [HERALDRY.]

Tennis. A game, in which a ball is kept in motion between opposite parties, who strike it with rackets.

Tenon (Lat. teneo, *I hold*). In Architecture, the end of a piece of wood or timber, diminished usually by one-third of its thickness, which is received into a hole corresponding to it in size, called a *mortise*, by which expedient the two are held jointed or fastened together.

Tenore or **Tenor** (Ital.). In Music, that part of a vocal composition which is sung by a high male voice.

Tenorite. A native protoxide of copper, which is found at Vesuvius in the form of small dark steel-grey laminae, also earthy and as a black powder. Named after Signor Tenore.

Tenrec. The name of a small insectivorous quadruped of Madagascar, allied to the hedgehog; it forms the type of the genus *Centetes*.

Tense (Lat. tempus, *time*). In Grammar, that modification of the verb which defines the time at which the action is conceived as taking place.

In the Aryan languages, the tenses are formed chiefly by combining the verb substantive with the root of the so-called verb active, passive, middle, or neuter. Thus the *future tense* is formed, in Greek, by the addition of *s*, belonging to the root *as*, to be, and the Latin by adding the root bhu, *to be*. The present tense is simply the name expressive of action or endurance, combined with the personal or demonstrative pronoun, thus δίδωμι = dadâmi = *give I*. The imperfect, in Greek, is formed by placing, before the root of the present, a prefix termed the *augment*. This augment Bopp regards as identical in its origin with the *a privative*, and as expressing therefore the negation of the present, as in Sanscrit uttamas is *the highest*, anuttamas (not the highest, and so removed beyond comparison, i. e.) *incomparable*; êka, again, is *one*, but anêka answers not to οὐδείς, *none*, but to 'not *one*,' i. e. *many*. Thus the Greek syllabic augment ε-τερπ-ον represents the Sanscrit a-tarp-am; and the explanation is found in the fact that this *a*, which at a later stage acquires a privative force, is really the demonstrative base *i* or *e*, as in the Sanscrit enâm, the Latin *enim*. Thus the augment would not deny the presence of an action, but, meaning simply *that*, i. e. 'not *this*,' it would transfer the action to the other side, in other words, to the time already past. No argument can be drawn from the circumstance that in Greek the negative appears always as *a*, the augment always under the form ε, as τέτυφα and τέτυφε both represent the Sanscrit tatôpa.

Like the future, the Greek aorist is formed by combination with the radical consonant of *as*, to be, as in ε-τυπ-σ-α, ἔτυψα.

The Latin aorist or preterite is formed after the same fashion, the combined root being that of *fu*, or *bhu*, to be, e.g. pot-ui, for pot-fui, the same suffix reappearing in *ama-vi*, *audi-vi*.

The older Latin futures are formed like the Greek, e. g. fac-s-o (faxo), as τυπ-σ-ω (τύψω). In French, the future is formed by using as a suffix the verb *to have*; in the old Norse dialect it is formed by means of *mun*, I think [MENU], e. g. komamunu, *they will come*, i. e. they *mean* to come, thus reproducing the Greek μέλλω, Sanscrit manyâ, *to mean*.

Forms apparently anomalous occur in some tenses; thus the Latin *amamini* is out of all analogy with the other passive persons, but is

explained on a comparison with the Greek participial form τετυμμένοι, although it differs from the latter in having renounced its gender and its verbal suffix. The same participial formation is seen in such nouns as *alu-mnus*, *vertu-mnus*, ge-mini = genimini, γενομένοι, *the twins*, i.e. those who are *born together*. The Latin *amaminor* is a plural case-ending of *amamini*, as in the EUGUBINE TABLES, *subator* occurs for the Latin *subacti*, and *screbitor* for *scripti*.

Latin preterites, such as *cucurri*, *tutudi*, have lost their augments, like the Greek ἔπεφνον, for ἐπεφενον. Preterites, such as *fugi*, *legi*, *fodi*, have, further, lost their reduplication, the vowel being lengthened to make up the loss of the consonant of the second syllable, as in the Greek aorists ἔφηνα, ἔψηλα, for εφανσα, εψαλσα.

The verb substantive reappears also in such terminations as the Greek ευω (δουλεύω representing an original δουλ-φευω, to *be* a slave, as the Latin potui is really *pot-fui*, I *was* able), and in the Latin form bundus, such words as *vitabundus*, *mirabundus*, having retained the participial force, as in the phrases vitabundus castra, mirabundus vanam speciem. The anomalous Latin futures of the third and fourth conjugations, as *audiam*, are simply present tenses of the subjunctive mood, used in place of the lost futures, as *audibo*.

The same suffix reappears in the Latin infinitive, as in the present pos-se, velle = vel-se; esse, *to eat* = ede-re; ferre = fer-se, φέρειν, *to bear*; and in the past tense, amavi-sse, fui-sse. The old forms dicse (dicere), scripse (scripsisse), correspond closely to the Greek δεῖξαι (δεικ-σαι), γράψαι (γραπ-σαι), and all exhibit the same combination with *as*, to be. The same suffix is found in the Umbrian future perfect, *convortust* answering to the Latin *converterit*, *amprefus* (fus, fust = fuerit) to *ambiverit*, *ambrefurent* (furent = fuerint) to *ambiverint*, *fakurent* to *fecerunt*, *dikust* to *dicerit*, pointing to such forms as *fak-furent*, *dik-fust*, &c.

The ending of the Greek aorist imperative τύψαι, γράψαι, is probably the termination of the LOCATIVE CASE, this ending having belonged originally to the present as well as to the aorist, τύπτειν being referred to τυπτεμεναι, which, by dropping the case-ending, left τυπτεμεν, from which was obtained the contracted form τύπτειν.

In the tenses of modern languages the combinations are commonly more prominent; but their origin is not always obvious at first sight. Thus the future of obligation is in English formed by a combination with the verb *shall*; but *shall* (the Gothic skal), which looks like a present, is really an old perfect, answering to Greek perfects like οἶδα, which retain the force of the present. This *skal*, meaning *I am bound*, meant originally *I have killed*; and as, according to Teutonic law, the guilt of manslaughter could be atoned by a fine, the word meant strictly *I am guilty*, ich bin schuldig, and therefore 'I owe the fine for having slain a man;' and so the phrase 'he shall pay,' resolves itself into the expression 'he is guilty to pay.'

In the same way the auxiliary *may* was, in its primary signification, *I am strong* (akin to Greek μέγας, the Scotch *muckle*, Eng. *much*), and was likewise a preterite, from a root which meant *to beget*, whence the Scotch Mac, *a son*, and Gothic magaths, the English *maid*, a daughter.

Tension (Lat. tensio, *a stretching*). In Mechanics, the force by which a bar or string is stretched. Thus, when a weight is suspended by a string, the tension at every point of the latter is equal to that weight.

Tensor. [QUATERNIONS.]

Tensor Muscles. In Anatomy, those muscles which tighten the part to which they are fixed; as the tensor vaginæ femoris, tensor palati, &c.

Tent or **Tinta.** A Spanish red wine, chiefly from Malaga and Gallicia.

TENT. In Surgery, a plug of lint used for dilating wounds: a piece of sponge which has been imbued with wax is termed *sponge-tent*.

Tentacle (Low Lat. tentaculum, *a holder*). This term is used by Savigny in a restricted sense to signify the elongated, filiform, inarticulate appendages of the mouth of Annelides, but is also applied to all appendages, whether jointed or not, which are used as instruments of exploration and prehension. Thus, the oral arms of the Polyps, the prehensile processes of Cirripeds and Annelides, the cephalic feet of the Cephalopods, the barbs of fishes, are termed *tentacles*.

Tenth. A Musical interval, being the octave of the third.

Tenths. The tenth part of the yearly value of all benefices, which was anciently paid, with the first fruits, to the pope. [FIRST FRUITS.]

Tentorium. The process of the *dura mater* which separates the cerebrum from the cerebellum; it is occasionally, as in some carnivora, ossified, and forms a bony shelf.

Tenues (Lat. *thin*). The three letters *k*, *p*, *t* in the Greek alphabet are so called, in relation to their respective middle letters *g*, *b*, and *d*, and their aspirates *ch*, *ph*, and *th*.

Tenuirosters (Lat. tenuis, *slender*, and rostrum, *a beak*). The name of a tribe of Insessorial birds, including those which have a long and slender bill.

Tenure (from Lat. teneo, *I hold*). The feudal relation between lord and vassal in respect of lands. It is a fundamental maxim of the feudal system that all lands were, or at all events must be deemed to have been, originally granted out by the sovereign, and are therefore holden either mediately or immediately of the crown. The greater portion of the land in England was actually so granted out by William the Conqueror to his followers, and the same principle of tenure, or holding of the king, became established soon after the Norman Conquest, even with respect to those lands which remained in the hands of the original English holders. All the landowners in

the country thus became the vassals of the crown, and held their lands subject to the performance of certain duties or services as the condition of their enjoyment. The land holden was therefore styled a *tenement*; the possessors thereof, *tenants*; and the manner of their possession, a *tenure*. When such tenants as held immediately under the king granted out portions of their lands to inferior persons, they became also lords with respect to those inferior persons though they were still tenants with respect to the king, and were accordingly called *mesne* or middle lords. According to Blackstone, there were four principal species of lay tenures: 1. Tenure by knight service; 2. Tenure in free socage; 3. Tenure in pure villenage; and 4. Tenure in villein socage. The tenant by knight service was bound to attend his lord to the wars for forty days in every year if called upon (a duty afterwards commuted for an *escuage* or money payment), and his tenure was subject to the further burthens of *aids* or assistance to the lord in ransoming his person if captive, in making his eldest son a knight, and in providing a portion for his eldest daughter; *reliefs* and *primer seisin*, or fines paid to the lord upon the death of the tenant; *wardship*, or the right of the lord to the custody and profits of the land during the minority of the tenant; *marriage*, or the right of the lord to dispose of his ward in matrimony; *fines*, on occasions of alienation; and *escheat*, or forfeiture of the land to the lord, on failure of heirs of the tenant or corruption of his blood by felony. The lord's right of escheat, however, was subject to the paramount rights of the sovereign, to whom the lands of traitors were forfeited absolutely—those of felons for a year and a day; but forfeiture to the crown was rather a punishment for an offence than an incident of tenure. Tenure in *free socage* was free from the obligation of military service, though subject to the incidents of *escheat*, of attendance at the lord's court, and of giving customary aids, and in some cases to the payment of an annual rent, and of a *relief* of one year's rent. The only method, originally, by which the tenant could convey away part of his lands was by *subinfeudation*, or by making a grant to another person, reserving services corresponding with those due to the superior lord, thus creating a subsidiary tenure, and becoming himself a mesne lord; but as from the nature of some of the burdens or services incident to feudal tenure, it was an advantage to the lord that his lands should be in the possession of his own immediate tenants, the practice of subinfeudation was prohibited by the statute of Quia Emptores, 18 Edw. I., and other statutes which, while establishing the liberty of alienating lands held by free tenure, provided that the purchaser should hold them, not of the vendor, but immediately of the superior lord. Tenures in pure villenage and in villein socage are the origin of our present copyholds. The lord of a tract of land usually granted part of it to freemen, to be held in knight service or free socage, part he reserved as his own demesne, and part he granted to his villeins or serfs, to be held by villein tenure, subject to the performance of agricultural services or other servile works. These lands were originally held literally *at the will* of the lord, but the right of succession of heirs and of alienation, which was at first a mere indulgence, came by custom to be established as a right, while the servile part of the services became gradually obsolete as the condition of the copyholders improved.

Besides the lay tenures above mentioned, there remains a tenure of a spiritual nature, called tenure in *frankalmoign* or free alms, being that whereby religious corporations held their lands. This tenure is said to have existed before the Conquest, and was subject to none of the incidents of feudal tenure, tenants in frankalmoign being bound to perform only those religious or spiritual services as an endowment for which their lands were bestowed. It is by this tenure that the lands of the church are for the most part held at the present day.

With the decline of the feudal system, the obligations attending tenure by knight service gradually degenerated into a mere machinery for extorting money, and upon the restoration of Charles II. an Act of Parliament was passed (stat. 12 Ch. II. c. 24), by which tenure by knight service, aids, and other oppressive burdens, were abolished, and all tenures, except frankalmoign, copyholds, and the honorary services of grand serjeanty (a species of knight service), were turned into free and common socage. It is by free socage, then, that all fee simple lands in England are now held. Quit rents are still sometimes payable, though the change in the value of money has reduced them to insignificance, and land still escheats if the owner dies intestate and without heirs, or is attainted in consequence of murder; but in other respects the feudal incidents of socage tenure, never very burdensome, have been abolished or become obsolete. The doctrine of tenure, however, still forms an integral part of the law of England: it is impossible really to understand the simplest conveyance of land without referring to its principles, and most of the technical rules of real property law may be readily accounted for by remembering that, although they may now appear arbitrary and without significance, they once formed part of a great system under which all the landholders in the country were united, for purposes of public policy, in the closest bonds of mutual dependence and support.

The English tenures may be studied in Glanville, in Bracton, in Fleta, in Littleton, with Coke's *Commentary*, or in Blackstone. It is necessary, however, to say that much which is contained in these later writers was antiquated

at the time in which they wrote, though, as is customary with literary lawyers, they treated that which was theoretically existent as though it was in full operation. For instance, Coke treats of villenage as still holding good in his time, though the law courts had solemnly decided that the custom was obsolete. (Prof. Rogers, *Agriculture and Prices in the Middle Ages*.)

Tenures, Scottish. Scottish tenures were five in number, viz. 1. Military, or *ward holding*; abolished with all its *casualties* or incidents by 20 Geo. II. c. 50. 2. By *mortification* or *mortmain*; which now only applies to manses and glebes, retained by the Act of 1587 as mortified to the church. 3. *Burgage holding*, by which the burgesses of royal burghs hold lands and houses within the burgh of the sovereign by service of watching and warding, &c. 4. *Blanch tenures*, by which the grantee or vassal is bound to pay to the superior annually a species of quit-rent or acknowledgment. 5. *Feu-holding*, by grant, with reservation of pecuniary services. [Feu; Tenure.]

Tepal. Another name for *petal*. Also the pieces of a perianth, being of an ambiguous nature, between calyx and corolla.

Tepejilote. A Central American name for the flowers of a species of *Chamædorea*, which, while still enclosed in the spathes, are highly esteemed as a culinary vegetable.

Tephroite (Gr. τεφρός, *ash-grey*). A native silicate of manganese, found at Stirling, Sparta, and New Jersey, in crystalline and granular masses of an ash-grey colour, turning black on exposure.

Tephromantia (Gr. τέφρα, *ashes*, and μαντεία, *prophecy*). Divination from the figures assumed by red-hot embers.

Tephrosia (Gr. τεφρός, *ash-coloured*). A widely distributed genus of *Leguminosæ*, containing many species, growing for the most part in the tropical or subtropical regions of both hemispheres. The leaves are covered with a grey silky down, and the flowers are usually in terminal clusters, but occasionally stalked in the axils of the leaves. *T. apollinea*, a native of Egypt and Nubia, furnishes a kind of indigo. The seeds, moreover, are made into an ointment, used to heal the wounds of camels. The leaves and seed-vessels of this plant are occasionally found mixed with Alexandrian senna. *T. cinerea* is employed in the West Indies to stupefy fish. The leaves and stems of *T. toxicaria* are used for the same purpose in the West Indies, the Feejee Islands, and elsewhere. The stems and leaves are pounded and thrown into a river or pond, when the fish speedily become stupefied; the larger fish are stated to recover if placed in fresh water, but the smaller ones perish. The roots of this plant are employed as an application in certain skin-diseases in the Mauritius, Surinam, &c.

T. purpurea is used medicinally in various ways by the natives of India. Thus, the roots, pounded and mixed with arrack, are used as a wash for the mouth, and in the form of ointment are applied in cases of elephantiasis, while the juice of the plant is used, mixed with honey, as an application to pustular eruptions on the face.

Tequesquite. A native crystallised carbonate of soda, which is found in several lakes in Mexico, and is used in the smelting of silver-ore.

Teraphim. A word used thirteen or fourteen times in the Old Testament, and commonly rendered by our translators *idols*. Bryant explains them as 'lunar amulets, or types of the ark in the form of crescents, supposed to have been invented by the patriarch Terah.' They were also consulted by the ancient Jews for oracular answers. (*Antiq*. iii. 321.) In later times, strange and horrible practices of witchcraft are described by Rabbinical writers in explaining this word. The teraph, according to Rabbi Eliezer, was made by killing a first-born child, opening the head, putting a gold plate with the name of the impure spirit under the tongue, &c. (See also the notes to Southey's *Thalaba*, book i.)

Teratolite (Gr. τέρας, *a sign*; λίθος, *stone*). A hydrated silicate of alumina, peroxide of iron, lime, magnesia, &c. from the coal formation of Planitz in Saxony. It is the *Terra miraculosa Saxoniæ*, which was formerly supposed to possess valuable medicinal properties.

Teratology (Gr. τερατολογία). That branch of physiological science which treats of the various malformations and monstrosities of the organic kingdoms of nature.

Terce Major. In Card-playing, a sequence of the three best cards.

Terebellum (Lat. terebro, *I bore*). The name of a genus of buccinoid pectinibranchiate Gasteropods, having an oblong shell with a narrow aperture, destitute of folds and ridges, and gradually enlarging to the extremity opposite to the spire.

Tereben. The liquid product obtained after the purification of oil of turpentine by sulphuric acid.

Terebinth-tree. [Pistacia.]

Terebinthaceæ (Gr. τερέβινθος). An order of polypetalous Dicotyledons established by Jussieu, and adopted by all botanists who unite *Anacardiaceæ* with *Burseraceæ*; but as these are now definitively separated, Jussieu's name has been abandoned.

Terebrantia (Lat. part. of terebro, *I bore*). The name of a section of Hymenopterous insects, characterised by the possession of an anal instrument organised for the perforation of the bodies of animals, or the substance of plants. The borer (*terebra*) is peculiar to the female, and is composed of three long and slender pieces, of which two serve as a sheath for the third; it is placed at the anal extremity of the abdomen, and the oviduct is continued into it. The females instinctively use this weapon to prepare a place for the deposition of their eggs, where the maggot may be incubated in safety and upon its exclusion be surrounded by already organised matter adapted

for its sustenance. Some genera select vegetables for the parasitic support of their young, as *Sirex* (Linn.), which infests the pine-tree; and *Cephus* (Latr.), which perforates the stalks of corn for the purpose of oviposition. Others, as the ichneumons, pierce the skins of insects, and deposit their eggs in the subcutaneous fatty and nutrient material. Some ichneumons are provided with long and extensible anal borers, which they insinuate beneath the bark of trees, and into crevices and fissures, where their instinct and peculiar antennal organs of sensation enable them to find the insect which may form a fitting nidus for the parasitic and carnivorous larvæ. Other ichneumons, with short terebræ, place their ova in the bodies of Lepidopterous larvæ, or in those pupæ which are readily accessible to their attacks.

The female ichneumons manifest a wonderful instinct at the season of oviposition in discovering the insects, as well mature as in their different stages of egg, maggot, caterpillar, and chrysalis, which are obnoxious to the wounds of the instrument from which the present section of *Hymenoptera* takes its name.

Terebratula (Lat. terebro). The name of a genus of palliobranchiate acephalous bivalve Molluscs, in which one of the valves is perforated for the transmission of a peduncle. The hole through which the peduncle passes is completed by a small detached calcareous piece.

Teredo (Lat.; Gr. τερηδών, *the ship-worm*). The name of a genus of acephalous Molluscs, which bore their habitations in submerged timber, and cause great mischief in sunken piles, ships' bottoms, &c. [BORING WORM.]

Terenite (Gr. τέρην, *tender*). A kind of altered Scapolite.

Tereus. In Greek Mythology, a king of the Thracians, or Highlanders, in Daulis, and husband of Procne, by whom he became the father of Itys. Hiding Procne away, he married her sister Philomela, cutting out her tongue. But Philomela found Procne, who killed her son Itys, and (like Tantalos) placed his flesh before Tereus, and then fled from his pursuit. According to some versions, all three were changed into birds; while others related that the sisters wept themselves to death in Attica.

Tergum (Lat. *the back*). In Entomology, this term signifies the upper or supine surface of the abdomen.

Term (Lat. terminus, Gr. τέρμα, *a boundary*). In Logic, the expression in language of the notion obtained in an act of APPREHENSION. A term may consist of one word, or of several; but every word is not capable of being employed by itself as a term; i.e. in logical language, *categorematic*. Adverbs, prepositions, &c., and also nouns in any other case besides the nominative, are syncategorematic, i. e. can only form part of a term; while a verb is a mixed word, being resolvable into the *copula* (or auxiliary verb) and the *term*, to which the copula gives *tense*, *mood*, and *position*; but an infinitive mood is a term by itself. Simple terms, or categorematics, are divided into *singular* and *common*. A singular term stands for one individual; as 'Cæsar,' 'the king.' It is obvious that these terms cannot be affirmed or denied (in logical phrase, predicated affirmatively or negatively) of anything but themselves. A common term stands for many individuals (which are called its significates), as 'man,' 'king.' These, it is evident, can be said (or predicated) of others; e.g. 'Cæsar is a man,' 'Frederick is a king.' The subject of a proposition, therefore, may be either a singular or a common term; the predicate must be a common term. Terms are said to be *univocal*, *equivocal*, *analogous*, &c.; but these are rather distinctions of language than of logic. They are also said to be 'of the first intention,' and 'of the second intention;' the first appearing to be words used in a vague and general sense; the latter, words used in a limited and specific sense, which they bear in some particular art or science. [PROPOSITION.]

TERM. On Shipboard, the name applied to the carved work under each end of the taffrail.

Term of Years. In Law, the term for which a lease is granted, or the interest acquired by the lessee. By a curious anomaly in our law, a term of years, although it may give the absolute right to the possession and enjoyment of real estate for a thousand years or more, is considered to be personal and not real property, and devolves accordingly, upon the death of its owner, to his executors or administrators, and not to his heir. For terms of years were anciently created for farming purposes alone, and a farmer of land was in early times regarded more as the bailiff of the landowner than as a person having an independent property of his own. His interest, such as it was, had nothing military or feudal about it, and was consequently exempt from the feudal rule of descent to the eldest son as heir-at-law. (Williams *On Real Property*.) Terms of years, at the present day, are created for many purposes, and long terms are often made use of in settlements, wills, &c. as convenient means of securing the payment of money. [SATISFIED TERM.]

Terms. In Algebra, the parts of any expression which are separated from each other by the signs + and − are usually called *terms*. The constituents of a term are called its *factors*, and the term itself is said to be *compound* if one of its factors itself consists of two or more terms. Thus, $ab^2 + (b-c)\,d^2 - a\,b\,c$ might be called an expression of three terms, each containing three factors; the second would then be called a compound term, since one of its factors $(b-c)$ consists of two terms.

TERMS. In Law, terms are four sections of the year appropriated to the transaction of particular business in the superior courts of common law and equity. They are now regulated by 11 Geo. IV. and 1 Wm. IV. c. 70.

Hilary Term begins the 11th, and ends the 31st of January.

Easter Term begins 15th of April, and ends the 8th of May.

Trinity Term begins 22nd of May, and ends the 12th of June.

Michaelmas Term begins the 2nd, and ends the 25th of November.

Whenever any one of these days falls on a Sunday, the following Monday is substituted for it; and if the days from Thursday before to Wednesday after Easter Sunday inclusive, or any part of them, fall within Easter term, such days are regarded as holydays, and the term is increased by an additional number of days at the end, and Trinity term proportionably postponed. During term, the three superior common law courts sit in banc; and all their business, with the exception of the trial of issues of fact, and matters of minor importance, transacted before a judge at chambers, was formerly then performed. The power of the courts has, however, been increased by recent statutes enabling them to transact term business in vacation time, which includes all the year, except the terms. During the vacation, also, the circuits are held, in which causes are tried and the gaols delivered. The Court of Chancery transacts its ordinary business in vacation as well as in term time, its sittings being regulated by the Lord Chancellor.

Terminal Velocity. The uniform velocity which a body obtains when, after falling through the atmosphere, the resistance of the air has become equal to the accelerating force of gravity.

Terminalia (Lat. terminalis, from terminus, *an end*). In Botany, a group of trees or shrubs, dispersed over the tropics of both hemispheres. The astringent fruits of several of them have long been employed for tanning and dyeing purposes by the natives of India; and are now brought to this country in considerable quantities, under the name of Myrobalans, and used chiefly by calico printers for the production of a permanent black. The principal kinds of Myrobalan are the Chebullic, the produce of *T. Chebula*, which are smooth and oval; and the Belleric, *T. Bellerica*, obscurely five-angled, and covered with greyish silky down. The seeds of *T. Catappa* are like almonds in shape and whiteness, but though palatable they have none of their peculiar flavour.

TERMINALIA. Annual festivals celebrated by the Romans in the month of February, in honour of Terminus, the god of boundaries. [TERMINUS.]

Terminists. In Ecclesiastical History, a name given to a class among the Calvinists whose tenet it is (or was, for such opinions hardly exist at the present day) that there are persons to whom God has fixed, by a secret decree, a certain *term* before their death, after which He no longer wills their salvation however long they may live. They instanced the cases of Pharaoh, Saul, and Judas, among others.

Terminology (a word coined from Lat. terminus, and Gr. λόγος). In every science or art, the definition of the words and phrases peculiarly employed in it (in other words, its *technical terms*) is called its *terminology*.

Terminus (Lat.). A Roman deity who presided over boundaries and frontiers. This god appears to have been Jupiter himself, regarded as the protector of boundaries (Ζεὺς ὅριος). The limits consecrated to him were not to be transgressed, and every year sacrifices, called *terminalia*, were there to be offered up, in order to keep them inviolate. The circumstance that no terminus was allowed to be under cover, and that a terminus existed on the Capitol, is a further proof of the identity of this deity with Jupiter or ZEUS.

TERMINUS. [STATIONS, RAILWAY.]

Termites (Lat. termes, *a bough* or *twig*). These insects constitute an extensive and important tribe of the Neuropterous order, confined to the warmer latitudes of the globe, and taking an important part in the comminution and destruction of dead and decomposing organised matter. The termites are all social, terrestrial; and are active, carnivorous or omnivorous, in all the stages of their existence, save that of the ovum, after which they undergo only a semi-metamorphosis. The mandibles are always strong and hard, but differ in relative size in different classes of individuals of the same community.

The tribe *Termitinæ* includes the genera *Mantispa*, *Raphidia*, *Psocus*, *Perla*, and *Termes* proper (now the type also of a family, *Termitidæ*, or white ants, as they are commonly called). These are characterised by four-jointed tarsi: but the wings are carried horizontally on the body, and are very long: the head rounded, and the prothorax short and square. The body is depressed, with the antennæ short; the mouth very similar to that of the *Orthoptera*, with the four-cleft lower lip: three ocelli, one rather indistinct; the wings generally but slightly transparent, coloured, with the nervures not forming a close network; and the legs short.

The termites peculiar to the tropical and adjacent countries are known under the name of *white ants*, and commit great ravages, especially in the larva state, in which they are called *workers*; these are like the perfect insect, but with the body softer, and without wings, and the head generally larger and destitute of eyes, or nearly so. They are united into colonies of incalculable numbers, and live concealed in the interior of the earth, trees, and other wooden matters, such as furniture, shelves, &c. in which they make galleries, forming routes conducting to the centre of their nests; so that these objects, of which the outer surface is (with surprising instinct) left uninjured, fall to pieces on the slightest touch. The nests of some species are external, but without any visible exit. Sometimes they are raised to a great height above the surface, like pyramids, occasionally surmounted by a solid roof, which, by their height and number, appear at a distance like a small village. Sometimes these insects affix their nests to the branches of

trees. Another kind, termed *neuters* or *soldiers*, and which Fabricius mistook for pupæ, defend the nest. These have a head much larger and longer; and the mandibles are very long, and cross over each other. They are far less numerous than the larvæ, and live near the outer surface of the nest, so that they make their appearance just when it is attacked: they are also said to compel the workers to labour. The demi-nymphs have the rudiments of wings, and in other respects resemble the larvæ.

When arrived at the perfect state, the termites quit their habitation, flying abroad during the evening and night in great numbers. Before morning, they lose their wings, and, falling to the earth, become the prey of birds, lizards, &c. Latreille conjectures that the act of coupling takes place in the air, as in the ants, and that the females alone occupy the attention of the larvæ for the establishment of fresh colonies. The abdomen of the female subsequently acquires an enormous size, from the innumerable eggs which it contains. The royal chamber occupies the centre of the habitation, and around it are distributed those which contain the eggs and provisions.

Some larvæ of *Termes varium* have eyes, and appear to have habits somewhat different to the rest, and to approach our ants.

Negroes and Hottentots are very fond of these insects.

Ternate (Lat. ternus, *three*, distributive). In Botany, a term applied when three things are in opposition round a common axis: a whorl of three.

Ternströmiaceæ (Ternströmia, one of the genera). An order of hypogynous polypetalous Exogens, consisting of trees or shrubs, chiefly tropical, many of them of great beauty, which, like the *Clusiaceæ* (*Guttiferæ*), have imbricated sepals and petals, indefinite hypogynous stamens, and a free ovary divided into cells with the placentas in the axis; but they differ from that order generally in their alternate leaves, hermaphrodite flowers, and usually curved embryo, much less fleshy, and often enveloped in albumen. These characters have, however, several exceptions, and the precise distinction between *Ternströmiaceæ* and *Clusiaceæ* is not easily traced.

Terpsichore (Gr.). In the Hesiodic *Theogony*, one of the nine MUSES, supposed in later times to preside especially over choral song and dancing.

Terra Cotta (Ital.; Lat. terra cocta, *baked clay*). The name given to statues, architectural decorations, figures, vases, &c. modelled or cast in a paste made of pipe or potter's clay and a fine-grained colourless sand, with pulverised potsherds, slowly dried in the air, and afterwards fired to a stony hardness in a proper kiln. [BISCUIT.]

Terra Japonica. The old Pharmaceutical designation of the substance now called CATECHU. It was formerly regarded as an earthy mineral.

Terra Ponderosa (Lat.). The old Mineralogical name of carbonate and sulphate of baryta. [BARYTES.]

Terra di Sienna (Ital.). A kind of Ochre of a brownish-yellow colour found near Sienna in Italy. It is used as a paint both in its natural state (*raw Sienna*); and after ignition, when it becomes of a rich chestnut colour, and is called *burnt Sienna*.

Terrace (Fr. terrasse). In Architecture, a raised natural or artificial bank for the purpose of affording a promenade.

Terræ Filius (Lat.). In Classical Latinity, a humorous designation of persons of low origin or obscure birth: terræ filii, *sons of the earth*. (Persius, *Satire* 6.) In the university of Oxford, by an ancient custom, abolished a century ago, a satirical Latin oration was read at the commemoration annually by an undergraduate, who assumed the title of Terræ Filius. [AUTOCHTHONS.]

Terre-plein (Fr.). In Fortification, the upper surface of the rampart where the guns are placed and worked. Its breadth should be about forty feet; and it is bounded outside by the parapet, and inside by the inner slope of the rampart. [FORTIFICATION.]

Terre-verte (Fr.). Green-earth. A species of Chlorite of a green or olive colour, found in Germany, France, Italy, and North America. The green-earth of Verona, formerly used as a pigment, is a variety of this mineral. [CHLORITE.]

Terrestrials (Lat. terrestris, *the earth*). The name of a section of the class *Aves*, corresponding to the orders *Rasores* and *Cursores*; also of a family of Pulmonated Gastropods, and of a division of Isopodous Crustaceans.

Terrier (Low Lat. terrarium, from terra, *the earth*). In Feudal Law, a description or enumeration of the various lands and tenements held in a manor, with the extent of the lands, the names of the tenants, and the rents or services due from each. The most ancient, valuable, and extensive terrier is that of Domesday. These terriers were often reviewed or acknowledged by the homage of the manor, and, forming as they did important evidence as to title, were preserved as the most valuable among national, royal, or private muniments. They are very important to antiquaries, as supplying much information on the distribution of land, and the social habits of the community.

The term is now usually applied only to *ecclesiastical* terriers, or catalogues of the lands and other temporal possessions of the church in each parish, directed by the 87th canon to be kept in the Bishop's Registry.

TERRIER. This name also denotes a small variety of dog, used for drawing foxes when they take to earth on being hunted.

Terror, Reign of. In the History of the French Revolution, this term has been generally applied to the period during which the executions were most numerous, and the country under the sway of the terror inspired by the ferocious measures of its governors, who had

established it avowedly as the principle of their authority. It seems to be most properly confined to the period between October 1793 (when the revolutionary tribunal, although constituted at an earlier time, was first put in permanent action on the fall of the party of the Gironde) and the overthrow of Robespierre and his accomplices in Thermidor (July) 1794. The agents and partisans of the system have been termed *Terrorists*.

Tertials (Lat. tertius, *third*). Tertials are the large feathers which take their rise from the proximate extremity of the bones of the wing, corresponding to those of the forearm near the elbow joint, forming a continuation of the secondaries. They are so long in some birds, of the snipe and lapwing kind, that when the bird is flying they give it the appearance of having four wings.

Tertian Fever. An intermittent fever or ague, the paroxysms of which return every other day. [AGUE.]

Tertiaries. In Ecclesiastical History, associates of the Franciscans, who acknowledged the *third* rule of Saint Francis, and seem connected with the Fraticelli and Beghardi of the thirteenth century.

Tertiary or **Cænozoic.** The uppermost of the three great natural divisions of stratified fossiliferous rocks. The term *tertiary* has reference to the original grouping of such rocks. The term *primary*, originally intended to include the older group (supposed to be non-fossiliferous), was afterwards found too inclusive and to involve a theory since abandoned, and is now no longer used. The fossiliferous members of the older series are now known as *palæozoic*; the term *secondary* includes the principal fossiliferous series developed in England; and the *tertiaries*, which are poorly developed in our island, are recognised as a third great natural division, although they were at one time regarded as modern and comparatively unimportant.

A very large proportion of the earth's surface is covered with rocks of this newest of the three geological periods, and it is now understood to admit of many great and important subdivisions. Some notice of the most remarkable of these will be found under the various headings referred to in the article DESCRIPTIVE GEOLOGY.

Tertiary rocks were originally thought to occupy basins, and to be, to a great extent, of freshwater origin. It is true that the deposits of this newer period are, in Europe, more broken and detached than the secondary rocks; but this is due to the fact that at the time of their deposit large tracts of land were coming into existence in this part of the northern hemisphere. Elsewhere, as in South America, the tertiary rocks are continuous deposits, fully equal in all dimensions to the largest secondary or palæozoic rocks of any one period, and a large proportion are marine.

Tertiary rocks are rich in fossils, and the organic remains yielded by them have naturally a greater resemblance to familiar modern species now living, than that which is seen in those of the secondary and palæozoic rocks.

It has long been known that vast deposits of lignite occur in tertiary rocks, corresponding in some measure with the deposits of coal of the palæozoic period, but greatly inferior in value. It is now known that true coal of excellent quality occurs in Hungary in large basins of the middle tertiary period.

Such of the metals as occur in veins in metamorphic rocks are generally less abundant in tertiary rocks, owing to the fact that those now at the surface have not yet undergone full metamorphosis. On the other hand, certain metals, such as gold, removed by abrasion or weathering from veins, and collected with sands or gravels, are almost entirely confined to these more modern deposits. Tin is also not unfrequently found in stream works.

The tertiary rocks pass by insensible gradations into those of modern date and recent formation. There is no abrupt change of any kind common to all parts of the world, either in reference to the tertiaries or other rocks.

The following tabular view of the tertiary and modern deposits in some detail will be useful for reference, as it shows the present state of knowledge on the subject:—

British.	*Foreign.*
RECENT.	
Marine deposits with human remains in Cornwall and in the Clyde estuary. Kitchen middens in Scotland. Lake dwellings of Ireland.	Kitchen middens of Denmark with bronze and stone weapons, &c. Lake dwellings of Switzerland. Marine deposits of Bay of Naples. Lake deposits of Cashmere.
INTERMEDIATE. (*Glacial.*)	
Cavern deposits, Brixham, &c. River valley alluvia of Ouse and Thames. Glacial drift, Scotland. Boulder clays, Norfolk. Elephant beds, Norfolk. Moel Tryfaen drift, with marine fossil shells, 1,400 feet above the sea.	Amiens gravels with sculptured flints. Liége cavern deposits. Dordogne cavern deposits. Gibraltar cavern deposits. Malta cavern deposits. Australian cave breccias. Rhine Loess. Old Nile mud in terraces. Sardinian marine strata. Glacial drift of Northern Europe. North American mastodon deposits.

N.B.—All these probably, most of them certainly, contain remains of human tribes inhabiting the country at the time of the deposit.

NEWEST TERTIARY. (*Newer Pliocene.*)	
Norwich clay with mastodon. Chillesford beds (Arctic shells). Bridlington beds (do.).	Tufaceous (marine) deposits in Ischia, Monte Somma, and skirts of Etna. Volcanic tuff (fresh-water) of Sicily. Deposits of Upper Val d'Arno.

(*Older Pliocene.*)

Suffolk (red) crag.	Antwerp crag.
Coralline crag.	Sub-apennine deposits.
	Aralo-caspian deposits.

MIDDLE TERTIARY.

(*Upper Miocene.*)

Sands over North Downs (?).	Antwerp (Edeghem) beds.
	Diest sands, Belgium.
	Faluns of Loire and Bordeaux.
	Eppelsheim sands.
	Vienna deposits (Dinotherium).
	Turin (Superga) beds.
	Greek deposits near Athens with fossil monkeys.
	Oeningen beds (Swiss) plants and insects.
	Madeira, Canaries, and Azores volcanic tuff, and limestone.
	Swiss molasse (marine).
	Siwalik deposits.
	North American (Atlantic coast) marine deposits.

MIDDLE TERTIARY.

(*Lower Miocene.*)

Hempstead beds, Isle of Wight.	Fontainebleau sands.
Bovey Tracey lignites.	Auvergne lacustrine deposits.
Isle of Mull leaf-bed.	Lower Bordeaux faluns.
	Mayence basin.
	North German lignites.
	Lower molasse (Switzerland).
	Middle and lower Limburg beds (Belgium).
	Nebraska beds.

LOWER TERTIARY.

(*Upper Eocene.*)

Isle of Wight beds, Bembridge, and St. Helens.	Montmartre gypsums.
Headon series and Barton clay.	Calcaire siliceux.
	Grès de Beauchamp.

(*Middle Eocene.*)

Bagshot and Bracklesham beds.	Calcaire grossier.
Alum Bay white clays.	Miliolite limestone.
	Nummulite beds of the Soissonnais.
	Claiborne beds (U.S.).

(*Lower Eocene.*)

London clay.	Dunkerque London clay.
Woolwich beds of plastic clay.	Plastic clay of France.
Thanet sands.	Bracheux sands.
	Nummulite formation of India.
	Flysch.

Tertium Sal (Lat.). An obsolete chemical term formerly applied to neutral salts, as being a third substance, resulting from the union of an acid and alkali.

Tertullianists. In Ecclesiastical History, a branch of the African Montanists; so named from Tertullian, who embraced Montanist opinions.

Teruncius (Lat.). A coin of ancient Rome, the same as the *quadrans* or *triuncis*, being the fourth part of the *as*, and consequently containing three ounces before the value was diminished.

Terza Rima (Ital. *third* or *triple rhyme*). A peculiar and complicated system of versification, borrowed by the early Italian poets from the Troubadours. The verses are the ordinary Italian heroic lines of eleven syllables (interspersed very rarely with ten-syllable lines). The rhyme is thus arranged: At the commencement of a poem or portion of a poem, verses 1 and 3 rhyme together, as do verses 2, 4, and 6; the third rhyme begins with verse 5, which rhymes to 7 and 9; the fourth is formed by 8, 10, and 12, and so on; and the poem or canto ends abruptly—the last rhyme, like the first, being on a couplet instead of a triplet. It is obvious that the rhyme is interlaced throughout, and continually in suspense, so that no pause can be found until the end of the poem or canto; as, at the end of every line, there must still be a rhyme incomplete. This continuity gives a very peculiar character to the metre, and renders it highly expressive of sustained narrative or passion, and the abruptness of the conclusion is often turned to good effect by masters of versification. This metre has been rendered celebrated by Dante, who wrote in it his *Divina Commedia*. It has been adopted by his imitators, of whom the latest, Vincenzo Monti, has used it to much advantage; and by Ariosto and other poets for their satires. Byron has adopted it in English, in his *Prophecy of Dante*; and it has been attempted by various translators.

Terzetto (Ital.). In Music, a composition in three parts.

Tesselated Pavement (Lat. tessella, dim. of tessera). In Ancient Architecture, a pavement formed of small square pieces of stone called *tesseræ*. They are frequently, indeed mostly, found inlaid in different colours and patterns, and with a central subject. They are embedded in cement, and rest on prepared hard strata.

Tesselite. A cube-like variety of Apophyllite of a peculiar tesselated or mosaic-like structure, from Talisker in Skye, and Naalsoe in the Faroe Islands.

Tessera (Lat.). In Architecture. [TESSELATED PAVEMENT.]

TESSERA. In Roman Antiquities, a die six-sided, like the modern dice; and thus to be distinguished from the talus, which had only three sides. Tickets or tallies used for various purposes were called *tesseræ*. Thus, guards were set at night in their camps by means of a tessera with a particular inscription, given from one centurion to another through the army; and in this way the word *tessera* seems to have come to signify the watchword or password delivered to the guard. (*Mém. de l'Acad. des Inscr.* vol. xxxvii.)

Tesseraconteris (Gr. τεσσερακοντήρης). A galley with forty banks of oars; one of the largest of monstrous vessels mentioned by ancient writers. Great doubts have been entertained as to the possibility of the construction of a vessel which, according to the received notions respecting ancient shipbuilding, must

have required about *four thousand* rowers; but it is seriously recorded that one was built for Ptolemy Philopater, probably for purposes of show only. [GALLEY; TRIREME.]

Tessular. A term applied in Crystallography to a system of crystals, including the cube, tetrahedron, &c.

Test (Lat. testis, *a witness*). In Chemistry, anything by which chemical substances are distinguished from each other: thus, infusion of galls is a *test* of the presence of iron, which it renders evident by the production of a black colour in water and other liquids containing that metal. In the same way sulphuretted hydrogen is a test of the presence of lead, and nitrate of baryta of sulphuric acid. In Metallurgy and Assaying, the porous crucible which absorbs the liquid vitrifiable oxide of lead and other metals combined with it is sometimes called the *test*.

Test and Corporation Acts. The popular names of the statutes 13 Ch. II. st. 2 c. 1, and 25 Ch. II. c. 2; by the first of which it was provided that all magistrates in corporations should take the oaths of allegiance and supremacy, and another oath renouncing the doctrine that it is lawful to take arms against the king; and should have received the sacrament according to the rites of the church of England within a year before their election. The latter statute extended these provisions to 'all persons that shall bear any office or offices, civil or military,' &c.; and introduced a new declaration against transubstantiation. These Acts, long esteemed the great bulwarks of the Protestant church, were nevertheless evaded by means of Acts of indemnity annually passed for the relief of those who had neglected to take the oaths. They were finally repealed in 1828 (9 Geo. IV. c. 17), as far as regarded the administration of the sacrament. A declaration was substituted, which was abolished in 1866. Locke, as well as many other eminent men, strongly objected to the principle of making a religious solemnity a test of citizenship; it was defended by Dean Swift.

Testa (Lat.). In Botany, the integuments of a seed.

Testa di Quaglia. The Italian name for *Martynia proboscidea*.

Testaceans (Lat. testa, *a shell*). This term was employed by Linnæus to signify an order of the class *Vermes*. It is applied by Cuvier to an order of his class *Acephala*, comprehending those which are provided with a calcareous shell.

Testacellus (Lat. testa). A genus of slugs; so called from their being furnished with a diminutive shell, which forms a shield or protection to the heart. Of this destructive genus the following species are British, and occasionally infest our gardens and nursery grounds: *Test. scutellum*, Sowerby; *Test. haliotideus*; *Test. Maugei*.

Testament. In Law. [WILL.]

Testament, Old and New. [BIBLE.]

Testator (Lat.). One who makes a will.

Testimony. [EVIDENCE; HISTORICAL CREDIBILITY.]

Testing. In Metallurgy, the operation of refining gold and silver by means of lead upon a vessel called a *test* or cupel. [CUPELLATION.]

Testudinaria (Lat. testudo, *a tortoise*). A genus of *Dioscoreaceæ*, remarkable for the rootstock or rhizome being wholly above ground, and coated with a bark-like corky or woody substance, which in time becomes deeply cracked and forms large angular protuberances, which may be compared to the shell of a tortoise; hence its generic name. These rootstocks are usually more or less globular, and frequently of a large size, some of them measuring four feet in diameter. Several slender climbing stems rise from their summit, and grow to the length of thirty or forty feet; these bear small entire more or less heart-shaped leaves, in the axils of which the short racemes of little inconspicuous greenish yellow flowers are produced. The species are natives of the Cape of Good Hope; the best known, *T. elephantipes*, is occasionally seen in greenhouses in this country, where it is commonly called the *elephant's foot*, in reference to its unwieldy rootstock. At the Cape it is known as Hottentot's Bread, the fleshy inside of its rootstocks having at one time afforded part of the food of the Hottentots, though now only eaten by baboons and other brute animals.

Testudinata (Lat. from testudo, *a tortoise shell*). The name of a tribe of Chelonian reptiles, of which the tortoise (*Testudo*) is the type. It has been sometimes used as synonymous with *Chelonia*, and as a name for the whole order.

Testudo (Lat.). A military contrivance adopted by the Greeks and Romans principally in attacking walls and fortified places. It was formed by a body of troops holding their shields above their heads, so as to overlap one another and form a kind of penthouse, which threw off the missiles of the enemy while the assailants were approaching the walls. The word properly means a tortoise, from the similitude of its shell to this contrivance.

Tetanus (Gr. τέτανος, *a straining*). A spasm of the whole of the muscles. It is frequently caused by lacerated wounds, and when it affects the jaw it is termed *lock-jaw.*. Spasms of the muscles of the jaw may, however, occur quite independently of tetanus or general spasm. Such cases are designated TRISMUS. In hot climates tetanus is sometimes produced by exposure to cold, or by suppressed perspiration, and it then sometimes admits of relief and cure; but when it is the consequence of a wound, it is usually fatal. In poisoning by strychnia, spasms of a tetanic character are observed.

Tetartin (Gr. τέταρτος, *fourth*). A name for Albite.

Tête du Pont (Fr. *head of a bridge*). In Fortification, a field work, generally open at the gorge, resting its flanks on the banks of a river, in order to cover one or more bridges.

Tethydans. The name of a tribe of Tunicated Acephalous Molluscs, of which the genus *Ascidia* (*Tethys* of the ancients) is the type.

Tethys (Gr. τῆθος, *an oyster*). A name applied by Linnæus to a genus of *Vermes Testacea*; and by Cuvier to a genus of Nudibranchiate Gastropods, characterised by having two rows of branchiæ along the back in the form of tufts.

TETHYS (Gr. Τηθύς). In the Hesiodic *Theogony*, a daughter of Ouranos (*heaven*), and Gaia (*earth*), and a sister of HYPERION, and Rhea, who intrusted her with the charge of HERA.

Tetracera (Gr. τετράκερος, *four-horned*). A genus of *Dilleniaceæ* consisting mostly of climbing shrubs, widely spread over the tropics of Asia, Africa, and America. The species have some astringent qualities. *T. potatori* is called the Water-tree at Sierra Leone, because its climbing stems yield a good supply of clear water when cut across. In Brazil a decoction of *T. Breyniana* and *T. oblongata* is applied to swellings of the legs, prevalent in that country; while in Guiana an infusion of the Tigarea (*T. Tigarea*, called *Liane rouge* by the French in Cayenne, from the red colour of its infusion) is employed in venereal complaints.

Tetraceros. The generic name proposed by Dr. Leach for the four-horned antelope.

Tetradites. A word used in several senses, all of them, however, bearing upon its original derivation from Gr. τέτταρες, *four*. 1. Among the ancients, children were so called who were born on the fourth day of the month; and such were believed to be unlucky. 2. The Manichees and others, who believed the Godhead to consist of four instead of three Persons, bore this name. And, 3. In Ecclesiastical History, different sects of heretics were so called, from the respect with which they regarded the number four.

Tetradrachm (Gr. τετράδραχμος). A common silver coin of the ancient Greeks, of the value of four drachms.

Tetradymite (Gr. τετράδυμος, *fourfold*, from its occurrence in quadruple crystals). A native sulpho-telluride of bismuth, generally found massive with a foliated structure, but sometimes in tabular crystals of a pale lead-grey colour, and with a metallic lustre, in the quartz rock of Brandy Gill in Cumberland; also in Hungary, &c.

Tetradynamous (Gr. δύναμις, *power*). In Botany, this term is applied to flowers which have six stamens, of which two are short, and separated by two pairs of longer ones.

Tetraeteris (Gr.). In Grecian Chronology, a cycle of four years, invented by Solon, to make the lunar year equal to the solar. This he effected by intercalating a month of twenty-two days at the end of two years, and at the lapse of other two years another month of twenty-three days, making in all forty-five days, which will be found to be the difference between the lunar and solar year after an interval of four years.

Tetragon (Gr. τετράγωνος, *four-angled*). A figure of four angles or corners. [QUADRANGLE.]

Tetragoniaceæ (Tetragonia, one of the genera). A small order of perigynous Exogens, sometimes united with *Portulacaceæ*, but differing from them essentially in their several-celled ovary. They are much more closely connected with *Mesembryaceæ*, and are often united with them as a sub-order, only differing in the usual absence of petals. They are succulent-leaved herbaceous plants, chiefly maritime, and are found generally within the tropics, in the South Sea Islands, in Southern Africa, and in the Mediterranean region.

The genus *Tetragonia* consists of herbaceous plants with four-cornered fruit, and one of the species, native of New Zealand, is cultivated as an esculent under the name of *New Zealand spinach*. This, although altogether inferior to genuine spinach, is valuable on account of its resistance to drought, and the great quantity of foliage that may be gathered from a single plant. It is an annual, of the easiest culture.

Tetragram (Gr. τετράγραμμος, *with four lines*). A figure formed by four right lines. [QUADRILATERAL.]

Tetragrammaton (Gr.). Among several ancient nations, the name of the mystic number four, which was often symbolised to represent the Deity, whose name was expressed in Hebrew by four letters, יהוה.

Tetragynia (Gr. τέτρα, and γυνή). In Botany, one of the orders of the Linnæan classification, comprising plants with four pistils.

Tetrahedral Co-ordinates. [CO-ORDINATES.]

Tetrahedrite. A native sulphide of copper of very complex composition; containing variable proportions of antimony, of arsenic [TENNANTITE], or of both antimony and arsenic (Grey Copper-ore), and sometimes of silver, or of mercury.

It is found both crystallised and massive in various Cornish mines, at Combe Martin in Devonshire, in Scotland, Ireland, Hungary Saxony, Transylvania, &c. The name has reference to the tetrahedral form of the crystals in which it usually occurs.

Tetrahedron (Gr. τέτρα, and ἕδρα, *side*). A solid bounded by four planes. It has also four corners or angles, and six edges. The regular tetrahedron is one of the platonic bodies. [POLYHEDRON.]

Tetrahedron, Fundamental, or **Tetrahedron of Reference.** [CO-ORDINATES.]

Tetralogy (Gr. τετραλογία). The name given to the collection of four dramatic compositions brought forward for exhibition at Athens by competitors for scenic honour. It consisted of three tragedies and a satyric drama. [SATIRE; TRILOGY.]

Tetrameter (Gr. τετράμετρος). A verse consisting of four measures; i.e. according to the Greek prosody, of eight iambic, trochaic, or anapæstic feet.

Tetrandria (Gr. τέτρα, and ἀνήρ). In Botany, the fourth class of the Linnæan system of classification, containing plants furnished with four stamens.

Tetrandrous. In Botany, this term is applied to a flower having four stamens.

Tetranthera (Gr. τέτρα, and ἀνθηρός, *flowery*). An extensive genus of *Lauraceæ*, chiefly found in the tropics of the eastern hemisphere, extending, however, as far north as Japan, and as far south as New Zealand, but very few being American. The majority are evergreen trees. In *T. laurifolia*, which is widely dispersed over tropical Asia, the leaves and young branches abound in a viscid juice, and in Cochin China the natives bruise and macerate them until the mass becomes glutinous, when it is used for mixing with plaster to thicken and render it more adhesive and durable. Its fruits yield a solid rank-smelling fat, commonly used in the same country for making candles.

Tetrao (Lat.; Gr. τετράων, *a bustard*). A name selected by Linnæus for an extensive genus of gallinaceous birds, characterised by a naked and generally red band which occupies the place of the eyebrow. This genus comprehended all the various species of grouse, partridges, francolins, quails, and tinamous; and the necessity for subdividing it was consequently soon recognised. Latham restricts the genus *Tetrao* to those species of which the feet are covered by feathers, and are without spurs, with naked toes, and a round or forked tail: these are the true grouse. The species in which the toes are feathered as well as the legs, called *ptarmigan*, form the genus *Lagopus*. Brisson separated from the Linnæan *Tetraones*, the partridges, francolins, and quails, under the generic title *Perdix*; and the obvious characters indicated by the common names of these tribes, have been made by later zoologists the grounds for as many distinct genera. The quails of the New World form the distinct genus *Ortyx*. The long-necked tinamous of America constitute the last genus (*Tinamus*, Latham) of the family *Tetraonidæ*.

Tetrapharmacon. An ointment composed of four remedies; viz. wax, resin, lard, and pitch.

Tetraphyline. A variety of Triphyline, from Keiti in Finland.

Tetrapla (Gr. τετραπλόος, *fourfold*). In Ecclesiastical History, the name of a Bible arranged by Origen in four columns, consisting of four different Greek versions; viz. that of the Septuagint, that of Aquila, that of Symmachus, and that of Theodotion. This work must not be confounded with the HEXAPLA.

Tetrapneumonians (Gr. πνεύμων, *a lung*). The name of a section of spiders (*Araneidæ*), comprehending those which have four pulmonary sacs.

Tetrapterans (Gr. τετράπτερος, *four-winged*). A name applied by some entomologists to the insects which have four wings, and which thus constitute an extensive primary division of the class.

Tetrarch (Gr. τετράρχης). The governor of a fourth part of a country. This was a title granted by the Romans to some tributary princes, whom they did not dignify with the style of king. Such were the sons of Herod the Great, amongst whom his dominions were divided after his death. (*Mém. de l'Acad. des Inscr.* vol. xxviii.)

Tetraspaston (Gr. σπάω, *I pull*). In Mechanics, a machine in which four pulleys all act together.

Tetraspore (Gr. τέτρα, and σπορά, *seed*). One of the forms of fructification found in some sea-weeds. It consists of little clusters of spores, in most cases four in number, but very rarely eight. Mr. Berkeley remarks that fruit of this form seem to be not mere modifications of the capsule, but rather of the nature of gemmæ, multiplying the individual without impregnation. It is called *tetrasporic*, and the separate bodies *tetraspores*. They are usually formed by the division (often unequal) of one globose endochrome, three of the four divisions only being in general visible, in which case the fruit is sometimes erroneously called *trisporic*. When all four are visible at once the division is said to be *crucial*. In some genera, however, the oblong or elliptic endochrome is divided transversely, when the division is called *zonate* or *annular*. The tetraspores may be simply immersed in the frond, when they are called *sori*; or contained in external warts or excrescences (*nemathecia*), or in proper leaflets (*sporophylla*), or, lastly, in elongated pod-like processes (*stichidia*). It is in the rose-spored Algæ that tetraspores are found.

Tetrastich (Gr. τετράστιχος, *in four rows*). In Poetry, a stanza of four verses.

Tetrastyle (Gr. τετράστυλος). In Architecture, a building having four columns in front.

Tetrathionic Acid. An unstable acid of sulphur containing oxygen and hydrogen. Its formula is $S_4O_6H_2$.

Tetter. An eruptive disease of the cuticle. [PSORIASIS.]

Tettiges (Gr. *grasshoppers*). An appellation assumed by the ancient Athenians in allusion to the boast that they were produced from the soil which they inhabited. [AUTOCHTHONS.]

Tettigonians (Gr. τέττιξ, *a grasshopper*). A section of Hemipterous insects, of which the genus *Tettigonia* is the type. It is synonymous with Cicadarians. [CICADA.]

Teucrium (Gr. τεύκριον). An extensive genus of herbs and shrubs belonging to the *Labiatæ*, widely dispersed throughout the world, but abounding chiefly in the northern temperate and subtropical regions of the eastern hemisphere. They are called *Germanders*. Several species were formerly reputed to possess medicinal virtues, but are now discarded except by

rustic practitioners. *T. Scorodonia*, the Wood Germander or Wood Sage, is an extremely bitter plant, with the smell and taste of hops, for which it is said to be substituted in Jersey. Of the other species, *T. Marum*, or Cat Thyme, causes sneezing, and was formerly employed in the preparation of Compound Powder of Asarabacca, but lavender-flowers are now generally substituted for it.

Teutates. In Mythology, a deity mentioned by Lucan (i. 445), in conjunction with Hesus and Taranis, as being worshipped with sacrifices not unlike those of MOLOCH.

Teuthidans (Gr. *τεῦθος, the cuttle-fish*). The family of Dibranchiate Cephalopods, of which the calamary (*Loligo vulgaris*) is the type.

Teutonic. A name assigned to that class of the northern division of the Aryan family of languages, which includes the High German, Low German, and Scandinavian dialects. From the fact that the English speak a low German dialect, it has been inferred that they are, like the Germans, a Teutonic people; but this conclusion, although it may be true, must be received with great caution. It has been already stated [LANGUAGE] that although words may be imported to any extent into the vocabulary of a language, yet the grammatical systems of languages can never be exchanged, and therefore that there cannot be such a thing as a mixed language. But it is not less a fact that a nation may adopt the language of its conquerors, while the new blood introduced by the latter may be altogether inadequate to modify materially the original population; and hence that a race may retain all its characteristics through successive waves of conquest, if the numbers of the invaders in each case bear but a slight proportion to the original inhabitants, and especially if the force of each later invasion falls rather on the previous conquerors than on the original possessors of the country.

There is a strong tendency at the present time to apply these observations to the ethnology of Great Britain; and it is argued that as philology cannot be taken as a sure guide for the ethnologists, we are thrown back on the evidence of history and the bodily and psychical characteristics of the people who form the subject of enquiry; that historical notices give no support to the idea that the numbers of the Roman military colonists were large enough to have any sensible effect on the British population, or that the Roman legionaries were purely Roman; that intermarriages with British women would have a constant tendency to absorb the new element; that if this was the case with the Roman soldiers, it would be so still more with the Saxon invaders, and that while these were too few to effect any material change in the original stock, they would in their turn suffer far more than the British inhabitants from the subsequent inroads and settlements of Danes and Normans; and that the effect of the Norman Conquest in particular would be still further lessened by the fact that the army of William was recruited largely from people closely akin to the British population of England. It is further argued that, although the Britons adopted the language of their Anglo-Saxon conquerors, yet there is a Cymric element in the English vocabulary, and still more that there survives a Cymric pronunciation which is not found among any genuine Teutonic people. It is also urged that a philological examination of Cymric dialects, as the Welsh, reveals a remarkable affinity with Greek dialects in words and forms which are not common to the Greek and Teutonic languages, while the Cymric pronunciation survives among the modern Greeks as among the modern English. It is also argued that the characteristics of the English resemble those of the ancient Briton much more than they resemble those of Teutonic peoples, and that they exhibit the closest resemblance to those of the ancient Greeks. This resemblance may be traced in their common love of athletic exercises, in their pugilistic skill, in their expertness as horsemen, in their excellence as oarsmen, in their horse-races and their hunting, in their prize ring and in their wrestling contests, for which the Cymric word ymsafael corresponds exactly with the Greek *συμπαλαίω*, the *πὺξ ἀγαθὸς Πολυδευκής* being found in the English boxer and prize-fighter.

The conclusion from these and other considerations, it is maintained, is, that the English are a non-Teutonic people, or, in other words, that they represent the original British population of this country, into which has been infused an appreciable, though small, proportion of Saxon, Danish, and Norman blood; and, further, that the English exhibit the highest phase of Celtic civilisation in modern times, as the Athenians and other Greek tribes exhibited the highest Celtic civilisation of ancient times. Whether these arguments are valid and these conclusions correct, it would be premature or rash to affirm; but it will be readily admitted that the enquiry is one of great interest, and that the evidence on both sides should be carefully and impartially weighed. (Pike, 'The English and their Origin,' *Westminster Review*, Oct. 1866, p. 340; *Fortnightly Review*, Oct. 1, 1866, art. 'The Origin of the English.')

Teutonic Languages. A name given to the dialects which are comprised under the High German, Low German, and Scandinavian branches of the Aryan family of languages. Of these, the English and Dutch belong to the Low German branch. These dialects cannot be directly derived from each other, any more than Greek can be derived from Latin, or Latin from Greek, or either of these from Sanscrit; and if they are traceable at all to a common source, this source must be found in a language preceding all dialects which are known to us historically. It need scarcely be said that the language of a tribe or nation is no *conclusive* evidence in questions of ethnology.

Teutonic Order. A military religious order, entitled Teutonic Knights of the Hos-

pital of St. Mary in Jerusalem, which sprang from a peaceful and insignificant beginning during the siege of Acre, in the third crusade. The first founders, in Dean Milman's words, 'were honest, decent, and charitable burghers of Lübeck and Bremen. After the disasters which followed the death of Frederick Barbarossa, when the army was wasting away with disease and famine before Acre, these merchants from the remote shores of the Baltic ran up the sails of their ships into tents to receive the sick and starving. They were joined by the brethren of a German hospital, which had been before founded in Jerusalem, and had been permitted, by the contemptuous compassion of Saladin, to remain for some time in the city. Duke Frederick of Swabia saw the advantage of a German order, both to maintain the German interests and to relieve the necessities of German pilgrims. Their first house was in Acre.' (*Latin Christianity*, book xii. ch. v.) They continued their kindly offices till the crusade of Frederick II., when, under Herman of Salza, the fourth grand master, the order rose to distinction. Their history is from that time transferred to the Baltic, and the interest of their annals centres chiefly in the antagonism of their claims to those of the kings of Poland. The grounds and results of this quarrel are exhibited in minute detail, in the work entitled *Lites ac Res Gestæ inter Polonos Ordinemque Cruciferorum*, edited by Count Dzialynski (Posen 1856).

The knights were invited into Poland by Conrad (regent for Boleslas V.), who sought their aid for the conversion or extirpation of the savage Rutheni, and assigned to them the territory of Culm on the Vistula, for a term of twenty years, as a crusading ground against the enemies of the Christian faith. Of this compact the knights deny all knowledge, but there seems little reason for calling it in question. Retaining possession of their territory, they were further placed by Vladislas IV. in temporary charge of the fortress of Gdansk, which they were to defend against the marquis of Brandenburg. This compact also was broken; and the order was condemned by the legates of Pope John XXII. to restore the fortress and give further compensation in money. For contempt of this sentence they were excommunicated; and Vladislas, finding the papal censures ineffectual, engaged them in the field, and in a battle fought in 1331 is said to have slain 20,000 troops of the order. That the campaign was carried out with frightful severity on the part of the king of Poland, is evident from the total silence of all the witnesses on this subject, in the suit between the order and the Polish kings tried before the legates of Benedict XII., their reply to the protest of the grand master Theodoric being simply the countercharge that the iniquities of the order had led to their summary chastisement. In this trial, which took place in 1339, it was proved that the knights found their way into Dantzig (Gdansk), owing to the weakness of Bogussa, who offered to put them in possession of the fortress until they should receive compensation in money for their aid in guarding the city. In the issue, the knights expelled Bogussa, promising, however, to restore the fort to him as soon as Vladislas paid them the stipulated sum. The next fortress gained by the order was that of Sweckze, which led to the submission of all Pomerania, a territory ceded in 1296 by its duke Mistiwog to King Przemislas. This second suit, like the first, was ended by a papal sentence in favour of the Polish king; but, as before, the sentence was disregarded, and, four years later, Kasimir the Great was obliged to yield up to the order the absolute possession of Cujavia, Culm, and Michalow. A third trial followed, at the council of Constance, when the documents on which the order founded its claims were all impugned, and chiefly on the ground of forgery. But the strength of the order lay in circumstances which could not be affected by ecclesiastical sentences: and thus, while the Knights Templars fell, the Teutonic knights profited by the remoteness of their province, and consolidated their power, until Albert of Brandenburg exchanged his title of grand master for that of Duke of Eastern Prussia, and laid the foundation of the modern Prussian monarchy. (*Edin. Rev.* July 1858.)

The order, however, still remained a separate institution, the seat of the grand master being at Mergentheim, in Swabia. By the peace of Presburg, in 1805, the emperor Francis II. gained the grand mastership with its rights and revenues. In 1809, the order was abolished by Napoleon, but it still has a titular existence in Austria.

Texalite. A variety of Brucite or hydrate of magnesia from Texas in Pennsylvania.

Texasite. A variety of Emerald Nickel from Texas in Pennsylvania.

Textile Fabrics. [WEAVING.]

Textuaries. Among the Jews, the sect of CARAITES, or Karaites, has been so called from its adherence to the text of the Jewish Scriptures.

Thaborites. [TABORITES.]

Thalamifloræ. The name of one of the four large classes into which De Candolle and others divide dicotyledonous plants. It includes all those orders in which the majority of genera have distinct petals, inserted with the stamens on the receptacle, under or immediately around the ovary.

Thalamus (Lat.; Gr. θάλαμος, *a chamber*). In Anatomy, the part of the brain from which the optic nerves have part of their origin.

THALAMUS. In Botany, the part on which the ovary is seated. The succulent red centre of a strawberry, or the core in the fruit of a raspberry, are the thalami of these plants. Some botanists call it the *receptacle*.

Thaler (Ger.). A Prussian silver coin, the value of which, expressed in English money, is 2 shillings and $10\frac{3}{4}$ pence nearly. In a thaler there are 30 silver *groschen*. The word has in other countries been corrupted into *dollar*.

Thalia (Gr. θάλεια, *blooming*). In the Hesiodic *Theogony* (77), one of the nine MUSES, regarded in later times as the muse of Comedy. According to Apollodorus (i. 3, § 4) she was the mother of the CORYBANTES by Apollo.

Thalidans (Gr. Θάλεια, one of the Muses). The name of a tribe of Tunicaries, of which the genus *Salpa* or *Thalia* is the type. [SALPA.]

Thalite. A kind of Soapstone of a pale yellowish-green colour, which is found diffused in the amygdaloidal trap-rocks on the north shore of Lake Superior.

Thallite (Gr. θάλλω, *to bloom*). The name given to certain acicular crystals of Epidote found in France and Spain.

Thallium (Gr. θαλλός, *a young shoot* or *twig*). This metal was discovered by Crookes in 1861, in a deposit obtained from the sulphuric acid manufactory of Tilkerode, in the Harz. (*Phil. Trans.* 1863.) The spectrum of this product furnished a singularly brilliant green line, which led him to examine it further, and suggested the above name. It has since been found in some varieties of pyrites and in the residue of the evaporation of certain mineral waters. It is a soft lead-like metal; its specific gravity between 11 and 12; its atomic weight 204; it tarnishes in the air; fuses at about 560°, and at about 600° takes fire and burns with a green light; in ductility, malleability, and tenacity, it much resembles lead. It forms alloys with most of the other metals. It forms two oxides, the most important of which is the protoxide (=Tl O). This oxide is soluble in water, furnishing an alkaline liquor which absorbs carbonic acid; it is yellow when anhydrous, soluble in sulphuric, nitric, and hydrochloric acids, and is thrown down from its solutions by sulphide of ammonium in the form of a dark brown sulphide. No precipitate is formed in solution of sulphate or nitrate of thallium by the caustic alkalies, but the carbonated alkalies give a precipitate in very concentrated solutions; chlorides, bromides, and iodides, give yellowish precipitates. The salts of thallium are very poisonous; they are colourless, when formed with colourless acids, and are easily decomposed by feeble electric currents.

Thallogens (Gr. θαλλός, *a shoot*, and γεννάω, *to bring forth*). The name of one of the primary divisions of the vegetable kingdom, comprising those cryptogams which are extremely simple in their structure, and exhibit nothing like the green leaves of phænogams. In the few cases in which there are leaf-like expansions, they are not arranged symmetrically round a stem, and are destitute of all trace of stomates and breathing pores; while in those lichens or *Algæ* whose stems are of long duration, though there may be something like centrifugal growth indicated by zones, it is of a totally different nature from that of acrogens The most definite point of distinction consists in the fact that the spores of acrogens when germinating produce either a cellular mass or plant, in which bodies called *archegonia* are formed, which by impregnation produce from an embryonic cell either a new plant or a spore-bearing capsule, while in thallogens no bodies corresponding to archegonia are ever produced.

Thallogens include the two vast tribes of Algals [ALGÆ] and Fungals, of which the latter are divisible into two main divisions, FUNGI and LICHENS.

Thallus (Lat.; Gr. θαλλός). This term, used to indicate a fusion of root, stem, and leaves into one general mass, is applied to that part of thallogens immediately bearing the fructification, more particularly to the cellular mass in which the perithecia are enclosed, or still more especially to the whole vegetative system of lichens.

Thammuz. The tenth month of the Jewish civil year, answering to part of June and July, and containing twenty-nine days. In Mythology, the Phœnician Thammuz is identified with ADONIS, the father (according to one legend) of PRIAPUS.

Thane (Sax. thegn, from thegnian, *to serve*). In early English History, the common title of the Anglo-Saxon military leaders called *Geraths* or companions (from sethian, *to journey*). The ealdormen were comprised among the thanes who are to be regarded as persons who become noble by service, which presupposed freedom of birth. The highest were the immediate thanes or ministers of the king. In Wessex and Mercia these thanes were called *twelf-hynde men*, whose wergild was twelve hundred shillings, i.e. six times that of the *ceorl* or two-hynde man. The dignity was connected with possession of land, the smaller thane possessing five hides, while the ealdorman held forty, this land being regarded as a reward for military service. But, in process of time, the land itself came to be considered a foundation of nobility, and the acquisition of five hides raised the simple freeman from the condition of a ceorl to that of a thane. The merchant who had thrice crossed the sea on his own account became entitled to this rank.

The thane was bound to military service, and obliged to appear on horseback, and had the right of appearing and voting in the witenagemot, the absent being considered as assenting to the resolutions of those who were present. Offices connected with the personal services of the king or the administration of justice were intrusted to thanes whose landed property furnished a sufficient guarantee for his conduct. (Lappenberg, *England under the Anglo-Saxon Kings*, part v.; Turner, *Anglo-Saxons*; Palgrave, *English Commonwealth*; Lingard, *Hist. of England*, ch. vii.)

Thapsia. A genus of *Umbelliferæ*, celebrated in very ancient times for its medicinal products—the Cyrenean Silphium or Laser Cyreniacum being generally supposed to have been the produce of one of the species. They are herbaceous perennials, all natives of the countries bordering on the Mediterranean. *T. garganica*, a native of Southern Europe from Spain

to Greece, and also of Algeria, where it is called Drias, is considered by the natives to be a specific against pain of all kinds, every part of the plant being held to be of equal efficacy. To camels, however, it is a deadly poison. Its root is purgative. *T. Silphium* is found on the mountains in the neighbourhood of the site of the ancient Cyrene, and is supposed to have afforded the gum-resin known to the ancients as *Laser Cyreniacum*, sometimes called *Assa-dulcis* to distinguish it from the assafœtida, both of which were included by the Greeks under the name *Silphion*, as also were other umbellifers.

Tharandite. A greenish variety of Pearl Spar from Tharand in Saxony.

Thatching (A.-Sax. thac; Ger. dach; Lat. tego, Gr. *στέγω, to cover*). Covering houses, stacks, or ricks with straw or reeds, in such a manner as to throw off the rain, and exclude excessive heat, or prevent its escape from within. The straw generally used in thatching is that of wheat, as being the longest and thickest, and the most durable. Next to wheat, rye straw is preferred, or, in default of that, the straw of oats; but the most durable of all thatch in cold countries is that formed of the reed (*Arundo Donax*, Linn.), or of the common heath or ling (*Calluna vulgaris*, Sal.). A very durable covering of the thatch kind is also formed of the spray of birch, of the bark of that tree, or of oak or pine, and of the chips and shavings made by hurdle-makers from the poles and shoots supplied by copse woods. Thatched roofs were formerly almost universal in cottage architecture; but they are now being supplanted by roofs covered with tiles or slates, which are much more durable, and not liable to catch fire; while the straw formerly used for roofs is much more profitably employed as litter for cattle, and thus turned into manure, and employed in reproduction—a process which, in agriculture at least, ought not to be deprived of any material contributing so essentially to its aid as manure.

Thaumatrope (Gr. *θαῦμα, a wonder*; *τρέπω, I turn*). The name given by Dr. Paris to an optical toy, the principle of which depends on the *persistence* of vision. A circle is cut out of a piece of card, to opposite edges of which two silk strings are fixed, by twisting which between the finger and thumb of each hand the disc is turned round with considerable velocity. On one side of the disc is drawn any object, as a chariot; on the other side, the charioteer in the attitude of driving; so that when the card is twirled round, we see the charioteer driving the chariot; or, in consequence of the duration of the impressions of light on the retina, we see at once what is drawn on both sides of the card. (*Library of Useful Knowledge*, 'Optics.')

Thea (Chinese tcha). The Botanical name of the genus of *Ternströmiaceæ* which includes the plants yielding Tea. The native country of the Tea-plant, like that of many others long cultivated by man, is uncertain. Hitherto the plant has been found by botanists in a really wild state only in Assam; and though China has not received so thorough an exploration by botanical travellers as to warrant the conclusion that it does not grow indigenously in that vast empire, yet a Japanese tradition, which ascribes its introduction into China to an Indian Buddhist priest who visited that country in the sixth century, favours the supposition of its Indian origin.

It was at one time commonly supposed that the two well-marked sorts of Tea, Black and Green, were the produce of distinct species; but it has now been ascertained that the Chinese manufacture the different kinds indiscriminately from the same plant; and botanists are now pretty generally agreed that the two supposed Chinese species, called *T. Bohea* and *T. viridis*, are nothing more than varieties of one and the same species, for which Linnæus' name, *T. chinensis*, is adopted, and of which the Assam Tea-plant (sometimes called *T. assamica*) is a third variety, or perhaps the wild type.

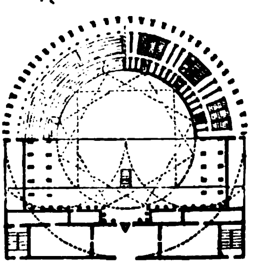
Though the produce of the same variety of the Tea-plant, the Black and Green Teas prepared for exportation are mainly the growth of different districts of China, the Black Tea district being situated in the provinces of Fokein and Kiangsi, and the Green in those of Chekiang and Ngan-whi; but the two kinds may be produced in either district, the difference being caused solely by the diverse methods of preparation. For the manufacture of Black Tea the freshly-gathered leaves, freed from extraneous moisture by a short exposure in the open air, are thrown in small quantities at a time into round flat iron pans, and exposed to gentle fire-heat for about five minutes, which renders them soft and pliant, and causes them to give off a large quantity of moisture; after which they are emptied out into bamboo sieves, and whilst still hot repeatedly squeezed and rolled in the hands to give them their twist or curl. They are next shaken out on large screens, and placed in the open air in the shade for two or three days. They are finally exposed in iron pans to a slow and steady fire-heat until completely dried, care being taken to keep them in constant motion to prevent burning. The chief difference in the manufacture of genuine Green Tea consists in the leaves being so long exposed to the air after rolling that fermentation does not take place, and in not being subjected to such a high temperature in the final drying; but the greater part, if not the whole, of the Green Tea consumed in Europe and America, is coloured artificially by the Chinese to suit foreign trade.

Physiologists are not thoroughly agreed as to the effects of tea upon the human system. Its most active principles are *theine*, a crystalline principle peculiar to tea and coffee, and *volatile oil*, to which its flavour and odour are due, and which possesses narcotic and intoxicating properties; but it also contains fifteen per cent. of gluten or nutritious matter, and more than twenty-five per cent. of tannin. The late Professor Johnstone endeavoured to explain its action by

stating that the *theine* lessened the waste of the body, and consequently lessened the necessity for and thus stood in the place of food, while the gluten actually nourished the body; but Dr. Edward Smith has recently shown these statements to be fallacious, only a trifling proportion of the gluten being taken up by boiling water, and the *theine* promoting instead of retarding vital action, thus increasing the bodily waste. He sums up its action thus: 'It increases the assimilation of food both of the flesh and heat forming kinds, and with abundance of food it must promote nutrition; whilst in the absence of sufficient food it increases the waste of the body.'

Theatines. A religious order in the Roman Catholic church, the earliest of the communities of *regular clerks*; it was founded in 1524 by St. Cajetan of Thiene. The members, besides the ordinary monastic vows, bound themselves to the duties of the cure of souls, preaching against heresies, tending the sick and convicts, while they pledged themselves to abstain from possessing property or asking for alms. (A. Butler, *Lives of the Saints*, August 7.)

Theatre (Gr. θέατρον, from θεάομαι, *I behold*). In Architecture, a building appropriated to the representation of dramatic spectacles. The theatres of the Greeks and Romans display some of the most extraordinary specimens of their power in the arts. (Donaldson's *Theatre of the Greeks*.) They seem to have been carried to perfection in the Greek colonies at an earlier period than they were in the parent cities. The first theatre of *stone* at Athens, called the theatre of Bacchus, was built in the time of Themistocles; and as there seems little doubt that the Athenians were the inventors of the drama as a regular scenic action, it is fair to presume that they were the first to regulate the form and proportions which necessity and pleasure dictated in their arrangement. The subjoined diagram shows the general form of the Greek theatre, which differed but little from



that of the Romans; and the instructions given by Vitruvius in the eighth chapter of his fifth book, as to the general outline of the plan, are as follows: 'Whereas in the Latin theatre the points of four triangles touch the circumference, in the theatres of the Greeks the angles of three squares are substituted; and the side of that square which is nearest to the place of the scene, at the points where it touches the circumference of the circle, is the boundary of the proscenium. A line drawn parallel to this, at the extremity of the circle, will give the front of the scene. Through the centre of the orchestra, opposite to the proscenium, another parallel line is drawn touching the circumference on the right and left; then, one foot of the compasses being fixed on the right-hand point, with a radius equal to the distance from the left point describe a circle on the right-hand side of the proscenium, and, placing the foot of the compasses on the left-hand point, with the distance of the right-hand interval describe another circle on the left side of the proscenium. Thus describing it from three centres, the Greeks have a larger orchestra, and their scene is further recessed. The pulpitum, which they call λογεῖον, is less in width; wherefore among them the tragic and comic performers act upon the scene, the rest going through their parts in the orchestra.' The ancient theatres were frequently used for the deliberations of the general assembly of the people on political matters, as we find from Tacitus and Ausonius. Notwithstanding the employment of those buildings in later times as quarries freely worked by the inhabitants of the cities in which they stood, there are still considerable ruins at Ephesus, Alabanda, Teos, Smyrna, Hierapolis, Cyzicus, Alinda, Magnesia, Laodicea, Mylasa, Sardis, Miletus, Stratonicea, Telmessus, Iasus, and Patara, all in Asia Minor; in Sicily, at Catana, Tauromenium, Syracuse, Argyrium, and Segesta. In Greece, ruins are still extant at Athens, Sparta, in the island of Ægina, at Epidaurus, and Megalopolis. According to Pausanias, the theatre at Epidaurus, built by Polycletus, surpassed all other Greek theatres in its beauty and proportions; but in grandeur and magnificence the Roman theatres far surpassed those of the Greeks; nor is this surprising, if we consider the population the former had to accommodate compared with that of the latter. For a very considerable period the theatres of Rome, like those of the Etruscans, were of wood; and Pompey, on his return from the war against Mithridates, was the first who constructed one of stone. This must have been of large dimensions, as it was capable of containing 40,000 spectators. Some remains of it are still visible. There were two other considerable theatres in Rome: the first built in the year 741 of the city, by Cornelius Balbus; and the second, which was begun by Julius Cæsar, but not finished till the time of Augustus, who dedicated it to his friend Marcellus. From the remains it appears that it was a specimen of great beauty and purity, as far as relates to the profiles of two of its orders, there being no vestiges of the upper order. The only other remains of Roman theatres are at Saguntum and Oranges, though the Romans usually erected theatres in their newly conquered cities, or at least embellished and improved those which they found on the spot.

The modern theatres of Rome are, perhaps, the worst in Europe. Italy, however, boasts

some beautiful examples; the chief being those at Parma (now in a very dilapidated state), Milan, Verona, Turin, Naples, and Bologna. We subjoin a short table of the width of the stage in a few European theatres:—

	feet
Milan	40
San Benedetto, Venice	40
Théâtre Français, Paris	40
Parma	40
Bordeaux	39
Turin	39
Argentino at Rome	36
Théâtre Italien, Paris	33

The properties most valued in theatres are: (1) facility in hearing, which is promoted by bringing the stage well forward into the house, and by forming the ceiling of thin deal like a great sounding board; and (2) safe and easy means of egress by fire-proof stairs in the event of alarm or fire. In the French theatres the ventilation is so regulated that about eighteen cubic feet of air per minute passes through the house for each individual, and the necessary current is sometimes maintained by means of fires. The fresh air is best introduced through perforations near the ceiling, and an air-shaft should be carried up from over the central chandelier for taking the foul air away. In the Prince of Wales' Theatre, in Liverpool, opened in October 1866, the stage is supported on pillars leaning backwards, so as to balance the tendency of the stage to come forward, from the fact of its surface being inclined. The foot-lights, too, are sunk below the level of the stage, which is sloped suddenly down to them, and each foot-light is encircled by a cylinder composed of green, red, and white glass, by turning which, light of either a green or red hue may be thrown on the actors and the scenes.

Thebaia or **Thebaine.** A crystalline alkaloid existing in very small proportion in opium. It has also been termed *Paramorphia.* Its composition is $C_{38}H_{21}NO_6$.

Thebaid. The name given to the heroic poem of Statius, which celebrates the civil war of Thebes waged between the two brothers Eteocles and Polynices. It consists of twelve books. Statius lived in the first century of the Christian era; but scarcely anything is known of his personal history.

Theban Year. In Chronology, the Egyptian year of 365 days 6 hours was so called. [SOTHIAC PERIOD.]

Theca (Gr. θήκη, *a case* or *receptacle*). A term used in Botany in various senses. It is applied to one of the lobes of an anther; to the case or urn containing the spores of mosses; to delicate tubes sunk in the shields of some lichens; and to certain simple kinds of fruit. In all cases it expresses a hollow case. It is now seldom used, except for the spore-vessel of a moss.

Thecaphore (Gr. θήκη, and φέρω, *I bear*). In Botany, the long stalk upon which the ovarium of some plants is seated; as in *Cleome*, and the Caper-bush.

Thecodactylus (Gr. θήκη, *a case* or *chest*, and δάκτυλος, *a digit*). A subgenus of night-lizards or geckoes, distinguished by having the subdigital scales divided by a median groove into which the claw can be retracted.

Thecodont (Gr. θήκη, and ὀδούς, *a tooth*). An order of extinct Sauroid reptiles, distinguished by having their teeth implanted in distinct sockets. One of the genera of this tribe, from the magnesian conglomerate near Bristol, has been called *Thecodontosaurus.*

Thecostomes (Gr. θήκη, and στόμα, *a mouth*). The name given by Latreille to those insects which have a suctorious mouth enveloped in a sheath.

Theft (A.-Sax. thyfthe). In Jurisprudence, the general name for the most ordinary class of offences against property; for which English law uses the peculiar designation of *larceny*. The difficulty of distinguishing between theft and those other species of fraudulent appropriation which are regarded by the laws of most countries as criminal offences, and, finally, that class which is only the subject of civil action, has given rise to a variety of definitions. By the French Code, art. 379, 'Whoever has fraudulently abstracted a thing which does not belong to him is guilty of theft.' By that of Bavaria, art. 209, 'Whoever knowingly of his own accord takes possession of movables not his, without consent of the person entitled thereto, but without violence to anyone, with intent unlawfully to hold the same as his property, is a thief.' As to English law on the subject, see LARCENY.

Theine. A crystalline principle peculiar to tea and coffee and a few other vegetable substances. It is identical with caffeine, has a slightly bitter taste, and is sparingly soluble in cold water and in alcohol. It melts at 454° C., and sublimes at a higher temperature. Caffeine, or theine, is a very feeble base, forming crystallisable salts with sulphuric and hydrochloric acids.

Theism. Etymologically, *theism* is the same word as DEISM; but a distinction is sometimes drawn between them, the name *theist* being applied to those who, while they reject the idea of an external revelation, maintain the existence of a Deity who directs the government of the cosmos by the constant exercise of His beneficent power; the Deist, on the other hand, being defined as one who holds that God, having before creation laid down a law or laws, leaves those laws to execute themselves without further action on His own part.

Thellusson Act. [PERPETUITIES.]

Thelyphthora. [POLYGAMY.]

Theme (Gr. θέμα). A subject proposed for discussion, whether orally or in writing.

Themis. In the Hesiodic *Theogony*, a daughter of Uranus (*heaven*) and Gaia (*earth*). In the Homeric poems she is the embodiment of law and orderly government, convening the council of the gods at the bidding of Zeus. The Hesperides are called daughters of Zeus and Themis.

Thenard's Blue. A compound of a splendid blue colour, obtained by heating a mixture of phosphate of cobalt with pure alumina.

Thenardite. A native anhydrous sulphate of soda, occurring in white, translucent or pellucid octahedrons, aggregated in crusts and druses at Las Salinas d'Espartines near Madrid, and at Tharapaca in Peru. It was named after the French chemist Thenard.

Theobroma (a word coined from Gr. θεός, and βρῶμα, *food*). A genus of tropical American *Byttneriaceæ*, consisting of small trees, with large entire leaves, and solitary or clustered flowers growing from the sides of the old branches and stems, and producing large pentagonal fruits, with a thick almost woody rind, and numerous seeds bedded in pulp.

T. Cacao was the first known species of the genus, and the Cacao or Cocoa of commerce is now usually said to be produced by it, though it is probable that several of the other species afford a considerable portion. Its fruits vary from six to ten inches in length and three to five in breadth, and contain between fifty and a hundred seeds, from which latter Cacao is prepared. When ripe, the fruits turn yellow outside; and they are then gathered by hand, and afterwards split open, and the seeds removed. These are then made to undergo a slight amount of fermentation for the purpose of developing their colour; and are afterwards exposed to the sun daily for about three weeks, or until they are thoroughly dry, when they are packed for exportation.

The cultivation of the Cacao-tree is spread over the greater part of tropical America; but the bulk of the Cacao-seeds brought to England comes from our West Indian colonies, principally from Trinidad and Grenada. To prepare them for use, the seeds are roasted in revolving metal cylinders, then bruised to loosen their skins (which are removed by fanning), and the cotyledons, commonly called *cocoa-nibs*, afterwards crushed and ground between heated rollers. This process softens the oily matter, and reduces them to a uniform pasty consistence. This is then mixed with variable amounts of sugar and starch to form the different kinds of cocoa, or sweetened and flavoured with vanilla or other substances for the formation of Chocolate. As an article of food Cocoa is exceedingly valuable from the large amount of nutritive matter which it contains; but as a refreshing beverage it is much inferior to either tea or coffee, owing to the large amount (50 per cent.) of fat which it contains, and also to the fact that the whole of the substance is taken into the stomach, while with tea or coffee only an infusion is drunk. It contains a peculiar principle which is called THEOBROMINE.

Theobromine. A white bitter crystalline substance contained in cocoa and chocolate (the produce of the fruit of the *Theobroma Cacao*). Its composition is $C_{14}H_8N_4O_4$.

Theocracy (Gr. θεοκρατία). A term expressing the government of a state immediately by God. Thus the government of the Israelites before the appointment of kings is spoken of as Theocratic; the nation, by its choice of an earthly sovereign, being represented as having rejected God, whom alone they had hitherto owned as their king.

Theocrasy (Gr. θεοκρασία, from κρᾶσις, *mixture*). In ancient Philosophy, a term invented to signify that intimate union of the soul with God in contemplation, which was considered attainable by the newer Platonists. Similar ideas are entertained by the philosophers of India, and by many religious sects. [QUIETISM.]

Theodicæa (Gr. θεός; δίκαιος, *just*). A justification of the dealings of Divine Providence with man. A work under this title was published by Leibnitz in the year 1710, in which he endeavours to prove that of all the possible schemes of government which God might have adopted, the one which actually exists in the world is the best. This is commonly known under the name of *optimism*.

Theodolite (a word coined from Gr. θεάομαι, *I view*, and δόλος, *stratagem*). A surveying instrument for measuring the angular distances between objects projected on the plane of the horizon.

In accurate surveying, when the instrument used for observing the angles is a sextant or reflecting circle, or such that its plane must be brought into the plane of the three objects which form the angular points of the triangle to be measured, the altitudes of the two distant objects above the horizon of the observer must be determined, and a calculation is then necessary to reduce the observed angles to the plane of the horizon. The object of the theodolite is to measure the horizontal angles at once, and thereby render the previous calculation, and even the observation of the altitudes, unnecessary.

It is easy to conceive, in a general way, how this object may be effected. A telescope with cross wires in its focus must be mounted so as to be movable both about a vertical and horizontal axis, in order that it may be brought to bear upon any object, whether in the horizon, or above or below it; and the proper means must be applied for measuring, with the utmost accuracy, the angle described about the vertical axis (which is the horizontal angle) in turning the telescope round from one object to another. It is consequently necessary to fix a graduated circle to the vertical axis, with its plane exactly horizontal, and its centre coincident with the vertical axis; and about the same axis a radial bar, firmly connected with the telescope, must revolve parallel to the plane of the circle, for the purpose of indicating the divisions passed over on the limb of the circle when the telescope is turned from the first object to the second. In order also to render the instrument subservient to the purpose of measuring altitudes, a graduated vertical arch is attached to the telescope; but as it seldom happens, in the practice of surveying, that the

objects observed are very much elevated above or depressed below the horizon, or that the vertical angles are required to be taken with the same degree of accuracy as the horizontal angles, the vertical arch is generally only a portion of a circle of smaller radius and less minutely divided than the horizontal circle.

The theodolite, as now generally constructed for the purposes of ordinary surveying, may be described as follows: The horizontal limb or circle consists of two circular plates, which turn freely on each other. The lower or graduated plate receives the divisions of the circle, and the upper or vernier plate has two sets of vernier divisions diametrically opposite. The vertical axis consists of two conical parts, one working within the other. The external part is attached to the graduated plate, and the internal to the vernier plate. The diameter of the under plate is somewhat larger than that of the vernier plate, and its edge is sloped off to receive the graduations; and portions of the opposite edges of the vernier plate are sloped off in like manner to receive the vernier divisions. The graduation is usually to thirty minutes of a degree, but is subdivided by the verniers into single minutes; and in a well-made instrument quarter minutes may be estimated by the eye. For the purpose of adjusting the plane of the circle to the horizon, the external axis is fitted into a ball, which works in a socket between two parallel plates held firmly together by the ball and socket, the under plate being connected with the staff-head supporting the instrument. But this adjustment may also be made (and in larger instruments is usually made) by a tripod support, having a foot screw at each extremity acting against a plate of metal supported by the staff. Upon the plane of the vernier plate are placed two spirit levels at right angles to each other, with their proper adjusting screws, by which the circle is brought accurately into the horizontal plane indicated by the levels. The centre of the circle is adjusted over the point which forms the centre of the station from which the observation is to be made, by means of a plummet.

Instead of the vernier plate described above, the index is sometimes formed by three radial bars connected with the internal vertical axis, each carrying a vernier at its extremity; and a fourth bar carries the clamp, by which the system is secured to the graduated limb.

The horizontal axis of the vertical limb (which is usually a semicircle) is supported by a frame firmly embedded in the vernier plate, and turning along with it about the vertical axis. The telescope has two collars or rings of bell metal, ground to a truly cylindrical form, on which it rests in supports permanently attached to the vertical limb, so that both move together in the vertical plane. The divisions on this limb are read off to single minutes by means of a fixed vernier connected with the frame, and so adjusted that the index points to the zero of the graduated arc when the optical axis of the telescope is truly horizontal. For effecting this adjustment, or determining its index error, a spirit level is attached to the telescope, at one end by a joint, and at the other by a screw, whereby the end is raised or depressed until the air-bubble stands at the middle of the glass tube. The telescope is then reversed; and if the air-bubble of the level still stands at zero, the adjustment is perfect; if not, the index error becomes known by bringing the level to the proper position, and may either be corrected or allowed for in the observations.

In some theodolites the telescope is supported in the manner of a transit instrument; i. e. the telescope and the horizontal axis on which it turns form one piece, and the vertical limb is a complete circle. By this construction the instrument becomes better adapted for determining the altitudes of stars, and consequently for finding the direction of the meridian and the azimuths of objects, or for other astronomical purposes. In fact, it becomes an altitude and azimuth instrument.

In theodolites for common topographical purposes the horizontal circle is seldom more than five inches in diameter; but as the double vertical axis gives the means of carrying round the telescope from the first object to the second without disturbing the graduated circle, and then, by clamping the vernier and graduated plates, of bringing it back, and the graduated circle along with it, to the first object, the measure of the angle may be repeated any number of times, exactly as with the repeating circle, and a very considerable degree of accuracy may be obtained even with a circle of this small size. [REPEATING CIRCLE.] But the principle of repetition is better carried into effect by means of a particular kind of stand or tripod, called a *repeating stand*, which turns round concentrically with the vertical axis of the theodolite; and recourse is usually had to this apparatus when the instrument is on a large scale.

As the accuracy of the observation must depend on the horizontal circle remaining perfectly fixed while the telescope and verniers are turned round, a second telescope, called a *watch telescope*, is sometimes attached to the horizontal circle beneath the limb, which, being directed to a fixed object, serves to detect any disturbance of the circle clamp, or accidental shifting of position while the upper telescope with the verniers is turned from the first object to the second. But this can scarcely be applied to the repeating theodolite.

The principal adjustments of the theodolite are: first, to rectify the line of collimation of the telescope; secondly, to make the axis of the horizontal limb truly vertical; and, thirdly, to adjust the zero of altitude. For the practical methods of making these adjustments in the case of the common surveying theodolite, and instructions as to the mode of observing, the reader may be referred to Simms's *Treatise on Mathematical Instruments*, 1834.

In geodetical operations, where very great

accuracy is indispensable, as, for example, in measuring an arc of the meridian, the instrument is constructed on a much larger scale. The great theodolite by Ramsden, belonging to the Board of Ordnance, which has been used for measuring most of the principal angles of the British Trigonometrical Survey, has a horizontal circle of three feet in diameter, and two telescopes of thirty-six inches focal length. A similar one of equal dimensions had formerly been constructed by the same excellent artist for the Royal Society, and was used by General Roy in his operations for connecting the observations of Greenwich and Paris towards the end of the last century, and also by Colonel Colby and Captain Kater for the same purpose in 1821. A full description of this superb instrument is given in the *Phil. Trans.* vol. lxxx. and in the first volume of the *Trigonometrical Survey of England and Wales.* A theodolite of equal dimensions, by Cary, has been employed in the measurement of the great meridional arc of India by Colonel Lambton and Sir George Everest. The French astronomers, in measuring their arc of meridian, used only the repeating circle; but in the more recent operations of the same kind in Germany and Russia, the geodetical angles were measured with the theodolite.

Theogony (Gr. θεογονία). A history of the descent and relationships of the various gods who were or are the objects of popular worship in the heathen world. In the articles METAPHOR, MYTHOLOGY, POLYONYMY, SYNONYMY, &c. it has been shown that the divinities of the Aryan Pantheon had their origin in mythical phrases relating to sensible phenomena. Men spoke of the sky (Dyaus) [ZEUS] as looking down on the earth, and on the sun as quickening, cherishing, scorching, or destroying all living things, till the names for sun and sky became the names of personal beings who had their abode in either. Gradually the deities so obtained were grouped together, and the sun might be described as the child of the sky [ZEUS], or of night [LêTO]; thus Indra, *the heaven*, became the parent of Ahana or Dahanâ, *the dawn*; and thus the children of Zeus or of Heracles were multiplied until their posterity branched into the genealogies of every tribe, city, or village; and hence the streams of divine and human generation are inextricably blended together. In process of time the task of grouping became a systematic work, which was carried out in various ways, as the mind of the writer led him. Thus the Homeric *Theogony* is far less developed and complete than the Hesiodic, while the latter has far less of a cosmogonical character than the Orphic. Thus, in the Homeric poems, Uranus and Gaia (*heaven* and *earth*) are known as great deities; but they do not appear (as in the Hesiodic *Theogony*) as arch-gods from whom Zeus himself is sprung through Kronos. The Homeric Cyclops is a wild shepherd: the Hesiodic Cyclôpes forge the thunderbolts of Zeus. In the *Iliad*, Briareos rescues Zeus from a conspiracy formed by Hêrê, Poseidon, and Athênê; in the Hesiodic *Theogony*, he helps him in the war against the Titans. In the *Iliad*, Zeus thrusts Kronos and the Titans into Tartarus without any opposition; in Hesiod there is a fierce strife, which in the hands of Æschylus receives its most magnificent colouring in the portraiture of PROMÊTHEUS. Thus the Hesiodic *Theogony*, while more complete, is more retrospective than that of the Homeric poems (whether *Iliad*, *Odyssey*, or *Hymns*), while the Orphic *Theogony* goes back still further to the great mundane egg produced by Chronos (*time*) out of Æther and Chaos. These developements are obviously reached by a systematic backward process, which in greater or less degree characterises all theogonies.

Theologium (Gr. θεολογεῖον). A small upper stage in the ancient theatre, upon which the machinery for celestial appearances was arranged.

Theology (Gr. θεολογία). Like all words expressive of abstruse or immaterial notions, this term may be traced to merely sensible ideas. The Greek θεὸς (the Latin *Deus*) denoted originally the visible heaven or sky [ZEUS]; and thus terms which signify literally the notation of cosmical phenomena have furnished a name for the science which treats of the nature and attributes of God and of His relations to man, or which, as it has been defined by some, gathers up, and combines in a logical form, all that may be inferred from the phenomena of the material and spiritual universe.

Lord Bacon divided this science under the following heads: (1) Inspired; (2) Natural, which he calls the first part of philosophy; (3) Appendices Theologiæ Inspiratæ, i. e. doctrina de legitimo usu rationis humanæ in divinis; doctrina de gradibus unitatis in civitate Dei; emanationes scripturarum; (4) Theologia tam inspiratæ quam naturalis appendix; doctrina de angelis et spiritibus. (*De Augm. Sci.* ii. 1.)

This classification obviously involves the need of a rigid definition of terms. In order to arrive at any clear conclusions, the precise meaning assigned to the words *natural theology*, *inspired theology*, *revelation*, and *reason*, must be exactly ascertained; and the controversies on these subjects seem to have arisen in great measure from the many shades of meaning through which these terms have passed, many of them being used by thinkers on opposite sides, and sometimes even by the same thinker in different senses in different stages of the enquiry.

Thus a definition of the term *natural religion* can scarcely be attained until the idea attached to the word *revelation* has been accurately determined. On the hypothesis that certain truths or facts were imparted to man on his first creation by a method different in kind from that by which he takes cognisance of phenomena and builds up the fabric of inductive science, natural religion resolves it-

self practically into a corruption of an original revelation, unless indeed there are cases in which tribes or nations have become so degraded as to lose every trace of the divine teaching thus imparted. The analogy of nature, according to Bishop Butler (*Analogy*, part ii. ch. ii. § 2), furnishes no presumption against a revelation when man was first placed on the earth; but the question whether mankind had a revelation made to them at that time is, he asserts, to be treated 'as a common question of fact.' If it be asserted that all knowledge of whatever kind is the result of revelation, then the awakening of new ideas in the mind as well as all knowledge gained by the cognition of facts form part of a great scheme of education which is coextensive with the whole existence of mankind from its commencement to its close. In this sense, apparently, Professor Max Müller asserts that the adoption of words to denote degrees of kith and kin marked certain definite stages in the history of the mind and in the moral developement of man; thus the addition of words like *law*, *right*, *duty*, *love*, to the dictionary of man, denoted the acquisition of new ideas, and 'it was a revelation, the greatest of all revelations, when the conception of a Creator, a Ruler, a Father of man, when the name of God, was for the first time uttered in the world.' On this hypothesis, the whole teaching of man becomes a homogeneous process, admitting of no definite line of demarcation between one portion of it and another, and needing only that ordinary sequence of events with which the common experience of mankind has rendered us familiar. The term RATIONALISM is not unfrequently employed to describe this theory, although the fitness of the name has been called in question.

The fact of an original revelation, apart from the normal operations of the mind, being assumed, it becomes necessary to determine the extent of that revelation. To this question Bishop Butler has in his *Analogy* furnished no answer; and by some this primeval revelation is regarded as involving little more than a precept of obedience and the duty of unhesitating submission, founded on the rational relation of God to His creatures. By others it has been maintained that this primeval revelation was supplemented by another immediately subsequent on the fall; that the latter was distinctly dogmatic; and that it set forth the existence (1) of an Infinite Being, whose perfect goodness arose not from external restraints, but from an unchangeable internal determination of character; (2) of a Trinity of Coequal Persons in the Divine Unity; (3) of a Redeemer who should hereafter assume man's nature and deliver from death and sin; (4) of a Divine Wisdom, which was with God from the beginning; and (5) of an Evil One who, having fallen from his throne in heaven, had become an antagonistic power, tempting men to their destruction.

These conclusions have been regarded by some writers as furnishing a key to all mythological systems, and especially to that of the Greeks, who converted the Trinity revealed to Adam into a Trinity of the three sons of Kronos, Zeus, Hades, and Poseidon, the tradition of the Redeemer being represented in Apollo, that of the Divine Wisdom in Athênê. To this it has been replied, that if the subject of the original revelation must be judged, in Bishop Butler's words, 'as a common question of fact,' its extent can be ascertained only by an impartial and unprejudiced examination of the documents in which it is embodied; that the statements of the book of Genesis do not propound the dogmatic belief involved in this hypothesis; that they speak only of one positive prohibition, of a beast which tempts the woman to disobey that command, of an attempt to transfer the blame from the man to the woman, from the woman to the serpent, of a sentence passed upon the latter that its head should be bruised by the woman's seed, and of a life of evil and labour imposed on the former, to be closed finally by a return to the dust from which man had been made; and that a dogmatic revelation of so minute a kind as that which many have discerned in the third chapter of Genesis would have been unintelligible to those who received it, and would soon have faded from their memory. To that interpretation of mythology which rests on this hypothesis, it has been replied that a few only of the characteristics of these mythopœic systems are thus accounted for, that these characteristics can be as well, if not more satisfactorily, accounted for in other ways, and further that, if the mythology of the Greeks or other races is a corruption of a primeval revelation, the ideas which were thus distorted and corrupted must have become fainter with the lapse of time; that truths thus perverted cannot become clearer and more definite in the process of corrupt developement; that the early literature of Greece exhibits a constantly increasing, not a decaying, sense of the Unity of the Divine Nature, and that the morality and philosophy of the Hesiodic poems is immeasurably higher, not lower, than that of the Homeric poems of a much earlier age; and that in point of fact the progress of man through POLYTHEISM to MONOTHEISM was very different from the course which the theory of a corrupted revelation would assign to it.

In another aspect, the subject of revelation is connected with that of the SUPERNATURAL. It is manifest that the hypothesis of relative miracle and the idea of absolute miracle are each equally consistent with the position that the increasing ignorance and corruption of man rendered it necessary that the Deity should interfere in order to recall them to obedience and a life of goodness or penitence; that these interferences were especially manifested in the history of the Jews, and culminated in the miracles which attended the preaching of the Gospel; and that this last and highest revelation was announced by a long series of prophets, who predicted the life, sufferings, and death of the Saviour. The arguments chiefly urged against these positions are found in the counter state-

ments that relative miracle, as being confessedly the manifestation of a higher law, cannot strictly be regarded as miracle at all; that the idea of absolute miracle is excluded by the notion of relative miracle, and that, if the latter idea had been set before the writers of the Old Testament or the New, the miracles which they related would in their eyes have lost all value and significance; that the actual occurrence of these events must be ascertained by an examination of the narratives, and must be treated as 'a common question of fact;' that the true idea of prophecy, as set forth in the book of Jonah, is not prediction, but the enunciation of a righteous law, and that the foresight of the Hebrew prophets was strictly the result of their observance of that law; and that the statements which are regarded as predictions relating to a remote future time were concerned only with the events or the results of causes at work in their own day.

These antagonistic opinions rest on conflicting notions of inspiration. These ideas have exhibited many phases, and have from time to time undergone indefinite modifications; but they may all be resolved ultimately into the conviction, on the one hand, that the inspiration of the prophets was different in kind from that by which men ordinarily are brought to the knowledge of moral and spiritual truth, and, on the other hand, that it differed from the latter only in degree.

A further antagonism is exhibited in opinions on the functions of the human mind in the cognition of truth, or, in other words, on the real relation existing between God and man. Thus by Mr. Mansel, following Sir W. Hamilton, it has been maintained that men are incapable of conceiving an Absolute and Infinite Being, and that, if they attempt to do so, they fall into self-contradiction; that men are, nevertheless, bound to believe in the existence of such a Being, while from the impossibility of our conceiving or knowing God's essential attributes, we are disqualified from judging what is or is not consistent with them. This position involves, it is said, the conclusion that, 'if a religion is presented to us containing any particular doctrine respecting the Deity, our belief or rejection of the doctrine ought to depend exclusively upon the evidences which can be adduced for the Divine origin of the religion; and no argument grounded on the incredibility of the doctrine as involving an intellectual absurdity, or on its moral badness as unworthy of a good and wise Being, ought to have any weight, since of these things we are incompetent to judge.' The question of the evidence to be adduced in favour of any system of religion is obviously a matter of history: the capability or incapacity of man to conceive of an Infinite Being is strictly a question of metaphysics; and on the latter, Mr. J. S. Mill (*Examination of Sir W. Hamilton's Philosophy*, ch. vii.) has replied that the idea of an Absolute Being is the idea of a Being *capable of existing out of relation to anything else*, whereas, in order to establish the human incapacity of conceiving such a Being, the definition should set forth an Absolute Being as one who is *incapable of existing in relation with anything else*; that this position is not maintained by any, inasmuch as all agree in speaking of the relations of God with the world and with man; that possible existence out of all relation is not incompatible with the notion of the Divine Being as a cause, or as absolute, just as the sun may be conceived as existing without any earth or planets to be illuminated by it; that anything which is capable of existing in relation is capable of being conceived or known in relation; that, if the Absolute Being cannot be conceived as cause, it must be that He cannot exist as cause, i. e. He must be incapable of causing; that, if an Absolute Being is unknowable in Himself, the relative attributes of an Absolute Being are unknowable likewise; that on this hypothesis, we do not know what wisdom, justice, and mercy are, as they exist in God; that, in applying these words to denote Divine attributes, we do not mean what the words assert, but something else, and that in this case we have no right to call them by names employed to denote certain qualities in man; that, if in affirming them of God, we do not mean to affirm the very same qualities which are found in man, differing only as greater in degree, we are neither philosophically nor morally entitled to affirm them at all.

But while the Eastern and Western Churches agree with most of the Protestant societies in maintaining that man, created pure and sinless, has, by a great aboriginal catastrophe, fallen from his first estate, and needs a complete renewal of his nature before he can be acceptable to his Maker, there is a wide difference between the theories on the mode and means by which this regeneration is effected. While Catholic and Protestant theologians alike agree in holding that man after the Fall needed the intervention of a Mediator, who should by the sacrifice of Himself atone for human disobedience, and in whom penitent sinners should be justified before God, the system which the former have raised on this basis differs widely from that of the latter. According to the Catholic belief, all mankind are by nature the children of wrath; by baptism they become children of grace, members of Christ, and inheritors of the kingdom of heaven. In this sacrament of admission into the Christian Church, they are brought to the laver of regeneration, and their nature undergoes a complete renewal. The grace thus received may be accepted thankfully or resisted; but, in the latter case, true penitence becomes the means for restoration to blessings already received, not for the obtaining of blessings to which hitherto they had been strangers. Hence the baptised child is taught that all that can be done for him has been done already, that the old things have for him passed away, and that he is a new creature; that, if by his own fault he goes away into the enemy's country and wastes his substance in riotous living, he may return to the house of his Father, from which he

has strayed, but that, while he can return to his original state of grace, he cannot possibly by penitence pass into a condition different from that which had become his birthright in and by baptism. Thus the sacrament of initiation imparts life; and a sacrament only can sustain the life thus imparted, and this sustenance is afforded in and by the Holy Eucharist. Thus the life of the Christian is wholly sacramental, being based on the mediatorial and priestly character of Christ, who is the only true priest exercising a divine and changeless priesthood. Christ alone has offered the only sacrifice which ever possessed the least power and virtue in itself; and by the offering of Himself once for all upon the cross, He paid back to the Father the ransom for all the sons of Adam, and atoned for the whole weight of sin brought in by Adam's fall. And further, as He only is a priest by His own inherent power, so by the virtue of His own priesthood they who are priests on earth exercise their office. They plead before God in the priesthood which Christ has Himself bestowed upon them, the sacrifice of His body and blood, so that the things which they do, they do not of themselves, but Christ performs them by their hands.

The mediatorial idea is thus made to pervade the whole province of theology. Man of himself cannot approach God; he can come near to the Father only through Him who is the Way, the Truth, and the Life. But He has appointed certain means, and insists on the performance of certain conditions. He has founded an organised society, in which alone the Christian can have assurance that he is receiving the spiritual food which is necessary to his soul's health; He has chosen certain men to whom He has delegated His own priestly powers, and charged them to admit others to their office, by the laying on of hands, to the end of time. These are the appointed stewards of His mysteries and ministers of His sacraments, the visible agents by whom He exercises His mediatorial functions. Thus in the world there is an order of men wielding powers which have not come to them from any earthly source, and kept up in an unbroken series which has received the name of the *apostolical succession*. [SUCCESSION, APOSTOLICAL.] From this doctrine the necessity of communion with the Catholic Church flows as a necessary consequence. Except under the condition of invincible ignorance, it is not enough to have a lively faith, or to do right acts; the Christian must exercise this faith and perform these acts where alone he has assurance that they will be effectual. Hence, for each person it becomes a truth that beyond the church there can for him be no salvation. But as to the nature of Catholic communion, there are large differences of opinion. According to the Orthodox (or Greek) and the Anglican theologians, all those societies which maintain the apostolical succession, and hold all that has from the beginning been declared to be 'of faith,' and in which the sacraments are rightly administered in form and matter, are portions of the Catholic Church, which is one in faith and practice, although divided by unhappy schisms which have sundered East and West, and compelled the Anglican Church to reject the Roman developements and assumptions. In opposition to this theory, Roman Catholic churchmen insist that under no circumstances can there be any warrant for schism, inasmuch as the grace given to the vicars of Christ is indefectible, that the church founded on the see of Peter is the eternal church against which the gates of hell shall never prevail, and that, as the Roman Church has in itself an absolute guarantee of infallibility, all resistance to its decrees and rejection of its claims to universal allegiance is without excuse.

With this system the Lutheran, Calvinistic, Zuinglian, and other Protestant theories are more or less antagonistic. The objections of Zuinglius himself were apparently far deeper than those urged by any other of the Reformers; but the latter as a body agreed in teaching that the mediatorial office of Christ was not exercised by a continual representation, on earthly altars and by the hands of a visible priesthood, of His own sacrifice on Calvary. As a body, they rejected the sacerdotal hypothesis; and although they still held that the sacraments were necessary or important means of grace, they maintained that their efficacy lay not in the right administration by a priesthood tracing its succession in unbroken line to the apostles, but only in the personal condition of the recipient. In their theory, all the children of Adam remained children of wrath and unfit objects for Divine love until they had been regenerated by a conscious personal conversion from unrighteousness to God. This regeneration was the direct gift of the Holy Spirit, which might be obtained before or after baptism, or possibly at the moment of baptism, but which in no case was tied up with baptism, or was its necessary consequence. The one indispensable condition was a lively or saving faith, *fiducialis apprehensio Christi*; and with the existence of this faith all other considerations became superfluous. This system necessarily interfered with the Catholic idea of Church communion, of Church discipline, of ritualism and ceremonies and its adherents, holding that the Catholic churches had corrupted the simplicity of the Gospel of Christ, made themselves the judges in the last resort of the nature and contents of that Gospel. They thus laid themselves open to the charges urged by their opponents, that on their own authority they presumed to run counter to the authority of that which alone could claim to be the Church of Christ, and that thus their basis involved the principle of scepticism and infidelity.

With these antagonistic theories has coexisted, possibly in all ages, a condition of thought which has been more especially characterised as rationalistic [RATIONALISM], and which has raised a protest not only against sacerdotalism, but against the system which especially claims the sanction of the Bible.

This school, if it can be termed a school, rejects in greater or less degree the ideas on which a sacrificial or mediatorial religion is ultimately based, and, asserting that God has in all ages and countries been educating the whole human race, declares that He desires for all men their highest good, and that this, the desire of a Mind which can feel no passion and know no change, must in the end be accomplished. Hence the final well-being of all mankind is insured by the very necessity of the Divine nature; and thus the distinction between a natural and a revealed religion becomes meaningless rather than superfluous. In points of detail, it asserts that the doctrines taught whether by Roman Catholics or by Protestants are inconsistent with ascertained facts or with the analogy of nature, and that in some instances, as by declaring that all persons dying impenitent will be endlessly tormented, they are degrading and demoralising. Such thinkers fall back, in short, on the examination of facts and the analysis of the ideas involved in such terms as law, education, punishment, justice and righteousness, and take their stand on the ground from which, as we have seen, Mr. Mill opposes the authoritative method of Mr. Mansel.

The preceding remarks may serve to give some idea of the three great lines of thought which are exhibited in the history of Christianity. We can only remark, further, that the subject of *natural* religion, as contrasted with a system promulgated on external authority, forms the basis of Bishop Butler's treatise on *Analogy*. His argument is chiefly negative, and rests on the statements that probability is the guide of life, that the evidence of religion is fully sufficient for all the purposes of probation, and that it would not answer the Divine purpose if it were as overbearing as is required, and that thus 'a serious apprehension that Christianity may be true lays persons under the strictest obligations of a serious regard to it throughout the whole of their life, a regard not the same exactly, but in many respects nearly the same with what a full conviction of its truth would lay them under.' This reasoning has not passed unquestioned; and in particular it has been urged that the natural world does not exhibit the analogy on which Bishop Butler lays so much stress, that no true scientific method puts aside exceptions or seeming irregularities as things which need not be regarded, or which may be better put out of sight; that true scientific method is never content with probabilities, but aims incessantly at the ascertainment of actual facts; that the progress made by man in civilisation may be measured by the degree in which he has attained to the knowledge of facts; that the course of nature suggests the idea of a Being who requires not an unquestioning obedience, but the full exercise of every mental faculty; and that the process of systematising without reference to certain known or acknowledged exceptions or difficulties is not admissible in true scientific method.

The opinions of theologians on the subject of human life and the condition of men after death are noticed in the article SOUL. The several tenets of dogmatic theology are treated under their respective headings.

Theopaschites (Gr. θεός, and πάσχω, *I suffer*). In Ecclesiastical History, a name given by the orthodox to the followers of Peter the Fuller, a usurping bishop of Antioch in the fourth century. Being strongly attached to the Monophysite opinions, he was charged with holding that all the three Persons of the Godhead were crucified. (Mosheim, fifth cent. part ii. ch. li.)

Theophany (Gr. θεοφάνεια). A word invented to signify the manifestations of God to man by actual appearance. These have formed a striking feature in most systems of religion. (See, on Pagan Theophanies, the fifth Dissertation of M. Foucher on the Hellenic Religion, *Mém. de l'Acad. des Inscr.* vol. xxxvi. p. 292.)

Theophilanthropists (Gr. θεός, and φιλάνθρωπος, *a lover of men*). A title assumed by a society formed at Paris during the first French revolution. The object of its founders was to establish a new religion in the place of Christianity, which had been formally abolished in France by the Convention, and had lost its power over the minds of large classes of the people. The Directory granted these philosophical sectarians the use of ten parish churches in Paris, where they held meetings for religious service; but the attempt to found a new sect was wholly unsuccessful. In 1802 they were forbidden the use of the churches by the consuls, and then ceased to exist.

Theophrastaceæ (Theophrasta, one of the genera). A small order proposed by Alphonse De Candolle for *Theophrasta* and a few other small genera, usually included in *Myrsinaceæ*, from which they differ chiefly in the presence of scales in the throat of the corolla, alternating with its lobes. They are generally regarded as a tribe of *Myrsinaceæ*.

Theorbo (Ital. tiorba). A lute of large dimensions, sometimes called the *arch-lute*, and formerly used for striking the chords of the thorough bass in accompaniments.

Theorem (Gr. θεώρημα, literally *a sight*). In Algebra, a theorem is frequently expressed by a formula, as in the BINOMIAL THEOREM and TAYLOR'S THEOREM. In Geometry, *theorems* are proposed for *demonstration*; they are thus distinguished from *problems*, in which a construction is proposed and a *solution* required. In Mathematics, a theorem is an expressed relation or truth.

Theoric Fund (Gr. τὰ θεωρικά, sc. χρήματα, literally *money for sights*). At Athens, the surplus of ordinary revenue, after defraying all charges of the peace establishment, was devoted to the formation of a fund for furnishing to all citizens not absent from Attica the sum (2 oboli) required as the price of seats at the great dramatic festivals. This gratuitous distribution of money (a measure carried by Pericles) was

made not from a mere purpose of insuring or increasing the pleasures of the citizens, but chiefly as a religious duty, the drama being in fact a solemn service offered in honour of the gods. This religious character extended to all Hellenic festivals; but the theoric fund, called by Mr. Grote the church fund of Athens, is perhaps the only instance of a charge laid upon the state for all expenses incurred in the worship of the gods. It was expressly provided that this fund should not be diverted to war purposes; and Demosthenes struggled for twelve years to apply these resources to the defence of the state, and succeeded only on the eve of the fatal battle of Chæroneia. (Grote, *History of Greece*, part ii. ch. lxxxviii.)

Theory (Gr. θεωρία). In Art, this word denotes the abstract principles of any art, considered without reference to practice.

Theory. In Science, this term properly expresses a connected arrangement of facts, according to their bearing on some real or hypothetical law. An *hypothesis* has been distinguished from a theory as an assumption which is conceived to afford a *support* to the discovered law. Thus some have imagined that the facts of gravitation are explained on the supposition of a subtle and all-pervading ether. Here it is evident that the *facts*, and therefore the *theory* or connected survey of them, are unaffected by the *supposition* in question.

Theosophists (Gr. θεόσοφος, *wise in the things of God*). A name which has been given, though not with any very definite meaning, to that class of mystical religious thinkers and writers who aim at displaying, or believe themselves to possess, a knowledge of the Divinity and His works by supernatural inspiration. In this they differ from the mystics who have been styled *Theopathetic*, whose object is passively to receive the supposed communication of the Divinity and expatiate on the results. [Mysticism.] The best-known names at this day of the Theosophic order are those of Jacob Böhme, Madame Guyon, Swedenborg, Saint-Martin. Schelling and others, who regarded the foundation of their metaphysical tenets as resting on divine intuition, have been called Theosophists, but with less exactness.

Therapeutæ (Gr. θεραπευταί, *worshippers*). A Jewish sect of the first century after Christ, who, with the Essenes, were the ancestors of the Christian monks and hermits. (Milman, *History of Christianity* i. 162; Montalembert, *Les Moines d'Occident*.)

Therapeutics (Gr. θεραπευτικός). The science which treats of the application of remedies, and the curative treatment of disease.

Theriaca (Gr. from θήρ, Ger. thier, Eng. deer, Lat. fera, Ger. eber, Eng. bear and boar, all denoting originally *a beast* [Treacle]). A name given in ancient Pharmacy to certain complex remedies supposed to be antidotes to poisons; they were usually in the form of confections. Some of the more celebrated have been transferred to comparatively modern pharmacopœiæ; such as the *Theriaca* of Andromachus, *Theriaca, Veneta Confectio Mithridatis*, &c.

Thermæ. [Bath.]

Thermal Springs. [Springs, Mineral; Springs, Thermal.]

Thermidor. In the French Calendar, the name of the eleventh month of the year in the French Republic. It commenced on July 19, and ended on August 17. The name is derived from the Gr. θερμός, *warm*, and was borrowed from the great heat which characterises that period of the year. It was the month signalised by the overthrow of Robespierre and the Reign of Terror, thence commonly called the Revolution of Thermidor; and those who boasted of having participated in it called themselves Thermidorians.

Thermo-electric Pile. An instrument composed of a number of alternate bars, generally of bismuth and antimony, by which small changes in temperature are rendered sensible by the production of an electric current, the presence of which is shown by means of a galvanometer. The thermo-pile was first constructed in a compact and efficient form by

Nobili, in 1834; but Melloni first applied this instrument to researches on radiation, for which purpose it has been invariably used since his time, as in its delicacy and accuracy it far exceeds all other thermoscopes. The figure represents a thermo-electric pile as used for investigations in radiant heat. One face of the pile A is bared to show the disposition of the bismuth and antimony bars, the ends only being seen. Attached to the other face is a conical reflector, C, which converges the radiant heat on to that face of the pile, where it is absorbed by a coating of lamp-black. The wires coiled down the sides, but insulated from the instrument, convey the electric current thus generated to the binding screws in the base B, whence the current is led by the wires *w w* to a neighbouring galvanometer. The action of the pile will be understood by a reference to the article Thermo-electricity.

Although the present use of the thermo-electric pile is confined to thermometric purposes, recent experiments lead to the hope that

it may at last become a powerful and profitable source of electricity. Prof. Bunsen, combining either copper pyrites or pyrolusite with copper, has obtained a battery, ten pairs of which give all the effects of a small Daniell's cell.

A *thermo-electric battery* has also been constructed by M. Marcus of Vienna, who employed for the positive metal an alloy composed of—

	parts
Copper	10
Zinc	6
Nickel	6

and for the negative metal an alloy of—

	parts
Antimony	12
Zinc	5
Bismuth	1

The bars of this battery were about six inches long and half an inch broad; the opposite junctions were heated by gas jets, and cooled by a current of water. With several pairs of such a battery a spark can be seen on closing the circuit, acidulated water decomposed, a metal electro-plated, an electro-magnet excited, and a piece of fine platinum wire can even be fused.

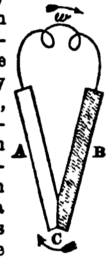
Thermo-electricity. When the junction of two dissimilar metals is heated or cooled, the free ends being joined by a wire, an electric current is generated. This developement of electricity by heat was discovered by Prof. Seebeck in 1822, and has received the name of *thermo-electricity*: in its theoretical and practical applications it is a fact of great importance.

The intensity of the thermo-electric current depends on two things: the nature of the metals employed, and the difference in temperature which exists between the two ends of the metal bars. The metals have been found by experiment to stand in the following thermo-electric order:—

Bismuth	Platinum
Nickel	Silver
German silver	Zinc
Brass	Iron
Lead	Antimony
Tin	Tellurium
Copper	Selenium

If two of these metals be taken, the more distant their position in the list the stronger is the current that will be generated. Hence the electro-motive force of bismuth and selenium is the greatest; but as it is generally impracticable to employ the last two metals on the list, bismuth and antimony form the usual thermo-electric couple.

The direction of the current can be understood by reference to the annexed figure. A represents a bar of antimony, B a bar of bismuth, the couple being soldered at the point C, and united by a wire *w*. On heating the junction C a current is generated, which moves in the direction of the arrow, i. e. from bismuth to antimony through the junction, and from antimony to bismuth along the connecting wire. On the other hand, if C be chilled, the current is reversed, now passing from antimony to bismuth across the junction. By uniting several of these couples so as to have alternate bars of bismuth and antimony soldered at their ends, the strength of the current can be greatly increased. Thus multiplying the number of pairs, and compactly arranging them in a cubical shape, Nobili constructed the first *thermo-electric pile*, an instrument which has become invaluable in researches on radiant heat. When one end of such a pile is heated, a current is produced which moves in the opposite direction when the other end is warmed. The existence of a current, therefore, depends, as already stated, upon the difference of temperature between the two opposite faces of the pile, and within certain limits the strength of the current is exactly proportional to this difference. It is on this account that the thermopile has become so important a thermoscope.



Thermo-electric currents can also be produced in a circuit formed of a single metal. If a straight and homogeneous wire be heated, no current is produced; but if the wire be coiled or knotted, a current will at once flow from the heated part to that in which the homogeneity has been destroyed. Two pieces of bismuth or two of antimony will also generate a current, if so placed together that their crystals shall occupy different relative positions. The origin of the thermo-electric current is probably to be found in the unequal propagation of heat in a conducting circuit. The electricity is not created; it results from the disappearance of an equivalent amount of heat. This can be confirmed by causing one face of a thermo-pile to be surrounded with water, whilst the other face is heated: the water becomes more rapidly warmed when the circuit is broken than when closed. A portion of the heat, which is conducted through the metal bars to the water in the former case, disappears in the latter, having been converted into electricity. This is further shown by a remarkable experiment of Peltier's, who found that cold was produced at a bismuth and antimony junction, when a current of electricity was sent from bismuth to antimony, and heat produced when the current was reversed.

Thermometer (Gr. θερμός, and μέτρον, *measure*). An instrument for measuring variations of temperature.

The principle upon which thermometers are constructed is the change of volume which takes place in bodies when their temperature undergoes an alteration. Generally speaking, all bodies expand when heated, and contract when cooled, in such a manner that, under the same circumstances of temperature, they return to the same dimensions; so that the change of volume becomes the exponent of the temperature which produces it. But as it is necessary not merely that expansion and contraction take place, but that they be capable of

being conveniently observed and measured, only a small number of bodies are adapted for thermometrical purposes. Solid bodies undergo so small a change of volume with moderate variations of temperature, that they are in general only used for measuring very high temperatures, as the heat of furnaces, of melting metals, &c. Instruments for such purposes are distinguished as *pyrometers*. [PYROMETER.] The gases, on the other hand, are extremely susceptible of the impressions not only of heat and cold, but also of pressure; and as their changes of volume are great even with moderate accessions of heat, they are adapted only for indicating very minute variations, or for forming *differential* thermometers. [DIFFERENTIAL THERMOMETER.] Liquids hold an intermediate place, and, by reason of their moderate but sensible expansion through the ranges of temperature within which observations have to be made for by far the greater number of purposes, are commonly used for the construction of thermometers; spirits of wine and mercury being the liquids most generally employed.

The properties which render mercury preferable to all other liquids (unless for particular purposes) are these: 1. It supports, before it boils and is reduced to vapour, more heat than any other fluid, excepting certain oils, and endures a greater cold than would congeal most other liquids, excepting certain spirituous liquors. 2. It takes the temperature of the medium in which it is placed more quickly than any other fluid. 3. The variations of its volume within limits which include the temperatures most frequently required to be observed may be presumed to be regular, and proportional to the variations of temperature. The spirit thermometer is used for observations of very low temperatures, or as a self-registering instrument for meteorological observations.

Construction of the Mercurial Thermometer.—A glass bulb, having a slender hollow tube attached to it, is filled with mercury, so that expansion or contraction can take place only by the rise or fall of the liquid in the tube. The diameter of the tube may be of any convenient size; but the smaller it is the larger will be the scale of the variations; and capillary tubes are usually employed. It is essential that the diameter of the bore be of a uniform width throughout; a quality which is tested by drawing up into the tube a short column of mercury, and measuring its length at the different parts with a pair of compasses. Not more than a sixth part of the tubes which come from the glass-house are found to be fit for the purpose.

Having selected a tube, the workman begins by blowing a hollow ball A upon one extremity of it, by means of an air-bag of caoutchouc (in order to avoid the introduction of watery vapour by blowing from the mouth). The length which the thermometer is to have is then marked, and above this point the tube is expanded into a second bulb B, rather larger than the first. When the tube has acquired its natural temperature, one of the bulbs is warmed, in order to expel the air from it, and the open end of the tube is plunged into distilled and well-boiled mercury. During the cooling, the mercury rises into the second bulb B, whence it is made to pass into A by placing this undermost, and expelling the air from it by heat, after which the mercury descends, from the effect of cooling. When the bulb A has been completely filled, and also a part of B, the tube is suspended horizontally over a fire, so as to be equally heated throughout, and the enclosed mercury boiled, in order to expel every remaining particle of air or humidity. The open end is then touched with sealing-wax, and the tube withdrawn from the fire, and placed in an upright position until it is cooled, when the bulb A and the portion of the tube under B will be filled with mercury. A portion of mercury is then expelled by heat, so that the column may stand at the proper height in the tube. The tube is then permanently closed by the blowpipe flame, at a point immediately below the bulb B, which is thus removed.

Fig. 1.

Graduation of the Scale.—In order that different thermometers may be comparable with each other, it is necessary that two points at least be taken on the tube or stem corresponding to fixed and determinate temperatures, the distance between which will determine the graduation. The two points which are now universally chosen for this purpose are those which correspond to the temperatures of freezing and boiling water. For the former, the bulb is surrounded by ice, and the stem marked at the point to which the mercury contracts; for the latter, the bulb is placed near to the surface of boiling water, and the stem marked at the point to which the steam has caused the mercury to rise. Several other minute circumstances must be attended to in the construction of delicate instruments.

The interval between the two fixed points on the stem may be divided into any number of degrees at pleasure, and the graduation continued above and below as far as may be thought requisite: the numeration may also be begun at any point whatever on the scale; but there are three methods of division so generally adopted as to require particular notice. The first is Fahrenheit's, which is used in this country, in Holland, and North America; the second, Réaumur's, which was formerly in general use in France, and is still followed in Spain, and some parts of Germany; and the third, that of Celsius, or the centigrade scale, now used in France, Germany, Sweden, and generally by scientific men in all parts of the world. In Fahrenheit's scale the interval is divided into 180 parts or *degrees*, as they are commonly termed, and the zero point is placed at thirty-two similar distances below the freezing point of water. The latter temperature was the lowest observed in Iceland, and was

erroneously supposed to be the lowest obtainable. In Réaumur's scale the interval is divided into eighty degrees, and in the centigrade into 100, a number recommended by its simple decimal character. To convert the degree of temperature on one scale into the corresponding one on either of the others is obviously only a matter of calculation, the following formulæ being as convenient as any:—

$$\begin{array}{l} C. \div 5 \times 9 + 32 = F. \\ R. \div 4 \times 9 + 32 = F. \\ F. - 32 \div 9 \times 5 = C. \\ F. - 32 \div 9 \times 4 = R. \\ C. \div 5 \times 4 = R. \\ R. \div 4 \times 5 = C. \end{array}$$

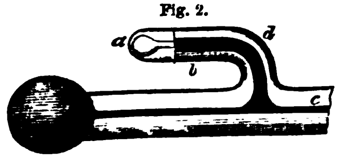
For temperatures below the freezing point, the calculations from or into Fahrenheit's degrees will of course be slightly modified. Thus, for the former, the division and multiplication will be made on the number obtained on previously subtracting the degree from thirty-two, and for the latter the number obtained on division and multiplication must be finally subtracted from thirty-two.

Register Thermometers.—In meteorological observations, it is of great importance to ascertain the limits of the range of the thermometer in a given period of time, during a day or night, for example, while the observer is absent. Many contrivances have accordingly been proposed for this purpose, but the two following are those most frequently used.

Phillips' Maximum Thermometer.—This is an ordinary mercurial thermometer with about half an inch of the mercury separated from the remainder in the stem by a minute particle of air. The detached portion is called the *index*, and remains in the part of the tube to which it may have been propelled by the expansion of the mass of the mercury, thus showing the greatest degree of heat to which the instrument may have been exposed in a given time. The index is made to recede or fall—or *set* as the operation is termed—by a dexterous jerk. Of course this thermometer must be suspended horizontally.

Casella's Mercurial Minimum Thermometer.—In this instrument the mercury falls during cooling, as usual, but does not rise again in the indicating stem, its expansion being provided for by a side outlet, as seen in the accompanying figure at *d*. This thermometer is filled with mercury as already described, but is graduated when the fluid occupies every portion of the

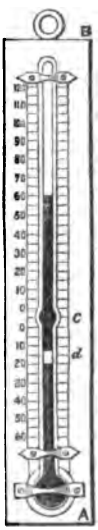
Fig. 2.



lower part of the instrument *except* the little pyriform chamber *a*. When it is suspended horizontally, and the little chamber emptied of its mercury by tilting up that end of the instrument, contraction on cooling will take place in the direction of least resistance, viz. down the long stem *c*, for the mercury is retained in the side tube *d* by a large amount of adhesion at the diaphragm *b*; an amount larger than can occur between the mercury and the glass in the long stem, because the surface of the diaphragm is always made larger than the total surface of the capillary tube of the stem. Expansion on heating the instrument also takes place in the direction of least resistance, viz. through an orifice in the centre of the diaphragm into the chamber *a*. The mercurial column in the stem, remaining at the lowest point to which it had contracted, thus correctly indicates the minimum temperature.

An ingenious, and at the same time simple, maximum thermometer has been devised by Mr. T. Twining. This instrument A B is a spirit thermometer, having about one-third of the way up the tube a small bulbous enlargement *c* in which at first is lodged a globule of mercury to serve as an indicator. So long as the spirit rises it flows round the mercury, but as soon as the spirit begins to descend the globule descends with it, lengthening as it does so into the form of a small cylinder *d*, the lower end of which marks on the lower scale the limit to which the spirit has descended from its highest point. Consequently, to ascertain at any time the maximum of temperature to which the instrument has been subjected, it is necessary only to add the degrees marked by the index on the lower scale to those marked on the upper scale by the extremity of the column of spirit. The thermometer is easily reset by warming it with the hand or breath until the globule of mercury rises into the little bulb; it is then laid flat until it attains the temperature of the air, when it is suspended vertically for observation. The advantages of this thermometer are its being used in an upright position, and its simplicity, which enables it to be made at a very low cost.

Fig. 3.



Thermonatrite. A native hydrated carbonate of soda, found as an efflorescence, and also in colourless and rectangular tabular crystals, in the steppes of Russia between the Ural and the Altai, the plains of Debreczin in Hungary, at the natron lakes of Lagunilla in Columbia, and in the Macarius desert in Lower Egypt. According to Haidinger, a saturated solution of carbonate of soda at a temperature between 80° and 100°, forms, on slow cooling, crystals of Thermonatrite, which differ in form from those of the common carbonate, and contain less water of crystallisation.

Thermophyllite. A mineral resembling Chlorite, occurring in crystals and grains in a

base which is probably amorphous Thermophyllite, at Hoponsuo in Finland.

Thermoscope (Gr. θερμός, and σκοπέω, *I view*). An instrument by which changes of temperature are indicated. The modification of the air thermometer, called by Leslie a *differential thermometer*, was claimed by Count Rumford as one of his own inventions, under the name of *thermoscope*. [THERMOMETER.]

Thermostat or **Heat Governor.** A self-acting physical apparatus for regulating temperature. A thermostat, the principle of which depends on the unequal expansion of metals by heat, was proposed by Dr. Ure for regulating the safety valves of steam engines with more certainty than the common expedients. (*Proceedings of the Royal Society* for 1830 and 1831, p. 67.)

Thermotics (Gr. θερμός, *warm*, from θέρω, akin to Lat. torreo, and Ger. dorren, Eng. *dry*). As *optics* relate to the phenomena which result from the action of *light* upon matter, so under the term *thermotics* may be included those effects which are caused by the action of *heat* upon matter.

By *heat* we understand that agent which, when communicated to the matter of our body, has the power to excite the sensation of warmth, and when communicated to the matter around us produces certain changes in the condition of bodies, through the particles of which it moves with more or less freedom. In this ability to be propagated by tangible bodies, heat differs from light, which, however, it closely resembles in many other respects.

Two views of the nature of heat were held by scientific men until recently. By some it was considered that heat was a highly attenuated and imponderable fluid, to which the name of *caloric* was given, and which could be added to or taken from substances. By others the materiality of heat was denied, these philosophers asserting in the words of Locke that what in our sensation is heat, is in the object nothing but motion. The former explanation is termed the *material theory*, and was the popular belief until ten or twenty years ago; the latter is known by the name of the *dynamical* or *mechanical theory*, and was advocated by Bacon, Locke, Rumford, Davy, and other eminent men, and is held by the philosophers of the present day. According to this hypothesis, which in its broad features has been established beyond doubt, the cause of heat is a certain vibratory motion of the ultimate particles of bodies. Accession of temperature means an increased motion; diminution of temperature, a lessened molecular disturbance.

If heat be thus a motion of the particles, we should be led to expect from what is termed the *correlation of force*, i.e. the convertibility of one force into another, that heat could be generated by ordinary mechanical motion, and that in turn work of this kind could be produced by heat. Both these facts have long been known. Savages know that dry pieces of wood rubbed together enable them to light their fires; school-boys by rubbing a metal button make it too hot to hold; mechanics find their tools become extremely heated when in active work; in all these cases the heat is not created by friction, it results from the conversion of the visible motion of the arm into an unseen molecular motion of the substance rubbed. Many familiar cases occur to everyone in which heat is produced by the partial stoppage, as in friction, or the complete stoppage, as in percussion, of the visible motion of a body. Thus, sparks fly from a knife on a grindstone, from the rails when a break is on the wheels of a train, from the collision of the shoes of a horse on a stony road, from the striking of the old-fashioned flint and steel. Warmth is produced by rubbing the hands, lucifer-matches are ignited by friction, and rifle-bullets often show signs of fusion, after their impact against the target. The converse is no less familiar, for the production of mechanical work by means of heat is seen on a grand scale in the steam engine; the heat of the burning coals being here the agent which moves a train or turns the wheels of a mill.

This mere qualitative relationship between heat and work was not enough to satisfy the minds of scientific men, especially the chemists, of the last generation. After Davy had liquefied ice by friction in vacuo, and Rumford had boiled water by machinery, many remained unconvinced by these experiments. But the second stage in the progress of scientific truth was at last reached, and the quantitative ratio between the work expended and the heat produced, and vice versâ, was firmly established by experiment. This second great advance in our knowledge is mainly due to the experimental researches assiduously conducted during the years 1842–49 by Dr. Joule, who by various mechanical devices succeeded in ascertaining the exact amount of heat resulting from the friction (in general of water) produced by a determinate mechanical force. Taking the mean of a great number of experiments, he expressed them thus: If a weight of 1 lb. be raised to a height of 772 feet, or 772 lbs. lifted one foot, as much heat will be generated by its descent and collision with the ground, as would raise one pound of water 1° Fahr.; or this amount of heat would be expended if used in the process of lifting the weight to a corresponding height. To avoid circumlocution, a pound raised one foot is called a *foot-pound*, and 772 foot-pounds is the so-called *mechanical equivalent of heat*.

Many interesting conclusions have been drawn from this equivalence. SHOOTING STARS are probably meteorites rendered incandescent by the friction which they encounter on entering our atmosphere; this friction, increasing as they approach the earth towards which they are drawn, finally dissipates them as vapour, sparing us from the serious consequences which would otherwise result from collision. The amount of heat which would be generated by the stoppage of the earth's orbital motion has

been calculated, and found to be equal to the combustion of 14 globes of coal equal to the earth in size. The falling of the earth from its present position into the sun would develope heat equal to the combustion of 5,600 worlds of coal, simply from the destruction of its acquired motion. This heat would be sufficient for the solar emission for a period of 95 years; whilst if the planet Jupiter were to fall into the sun, the heat generated would furnish a supply of solar heat enough to last for 32,240 years. The heat and light of the sun have therefore been reasonably attributed to the continual falling into its mass of cold asteroids circulating around it. Astonishing as these conceptions appear, they are not untrue or exaggerated, for they are based upon a great natural law, discovered by the strictes texperimental enquiry.

A force is known only by its effects on matter, which it thus renders cognisant to our senses. One of the most evident of the actions of the force of heat on matter, is its power of dilating the substances to which it is communicated. After thus causing an *expansion* of the substance, i.e. increasing its volume, the further application of heat produces a change in the state of the body, if a solid rendering it liquid, and if liquid rendering it gaseous; a process accompanied, in general, by a considerable enlargement of bulk. For equal increments of heat, solids expand less than liquids, and liquids less than gases.

The *expansion of solids* is so small that it requires the aid of multiplying apparatus to render it sensible. Many of the instruments constructed for this purpose can also be used for measuring high temperatures, and hence they bear the general name of *pyrometers*, which have already been fully described. [PYROMETER.] All solids do not expand equally for equal additions of heat; the metals, as a rule, expanding most. The *coefficient of expansion* of a body is the amount of dilatation which it undergoes when heated one degree. If, as is usual, only the length of the substance be measured, it is called the *linear coefficient*; the total or cubical expansion can be obtained by multiplying this number by three. In the following table are given the linear coefficients of expansion for 1° C. of several well-known substances:—

Expansion of Solids.

Glass	0·0000086
Platinum	0·0000088
Cast iron	0·0000112
Wrought iron	0·0000122
Gold	0·0000146
Copper	0·0000172
Brass	0·0000188
Silver	0·0000191
Tin	0·0000217
Lead	0·0000286
Zinc	0·0000294

Dr. Matthiessen has of late determined the expansion of metals and alloys by weighing them in water kept at different temperatures, and has proved that the coefficients of expansion of metals are not quite regular even between 0° and 100° C., and that the coefficient of expansion of an alloy is equal to the mean of the coefficients of expansion of the volumes of the metal composing it.

Owing to the nearly equal expansibility of platinum and glass, chemists are able to fuse platinum wires into glass tubes, and thus readily construct an apparatus which bears changes of temperature without fracture, a result which could not be obtained if the coefficients of the two substances were different. The difference in the expansion of certain metals has been practically applied in the construction of compensating pendulums. Of these there are various kinds, but the object in each is to neutralise the increase of length in the pendulum rod, resulting from an augmented temperature, by lifting to a corresponding extent the centre of gravity of the pendulum. This is obtained in the gridiron pendulum by the expansion of alternate steel and brass bars, of different lengths, which support the bob. In the mercury pendulum, the bob, instead of being solid, consists of a glass cylinder containing mercury: a rise of temperature causes the pendulum rod to lengthen, thus depressing the bob, but at the same time the mercury expands; and as it can only rise, it lifts the centre of gravity through an equal space, mercury being more expansible than the steel of the pendulum rod. The compensation balance in watches also depends on the unequal expansion of different metals, which are so juxtaposed that opposite effects shall be produced by their dilatation. The force exerted by a body in expanding or contracting is enormous, and has been made use of in the arts; the tires of wheels are put on, and rivets are used whilst red-hot, so that on the cooling of both the contraction which ensues closely binds the parts together: the bulging walls of buildings have even been straightened by the contraction of iron bars stretched from wall to wall and tightly screwed up when red-hot.

The *expansion of liquids* can be determined by enclosing them within a graduated vessel, and noting the increase in bulk for a given rise in temperature. Such an instrument is the ordinary mercurial or alcohol thermometer, which registers differences in temperature by the dilatation or contraction of the enclosed liquid. [THERMOMETER.] It is evident, however, that this measurement is less than the real dilatation, for whilst the liquid expands the containing vessel also enlarges in bulk; hence the rise of the mercury in a thermometer is due to the difference in expansion between the liquid and its glass envelope. The absolute expansion of a liquid can be found by adding to this, which is termed the *apparent expansion*, the expansion of the material of the vessel. Dulong and Petit, and more lately Regnault, have adopted another means for determining the absolute expansion of mercury, which was found to be practically uniform between the freezing and boiling points of water. This, however, is not the case with many other liquids, the rate of expansion generally increasing as the temperature rises.

The most volatile bodies are, as a rule, the most expansible; the extremely volatile liquids which result from the condensation of gases enlarge in bulk even more rapidly than when in the gaseous state. Thus, liquid carbonic acid has been found, with the same rise in temperature, to expand four times as much as air.

In certain states the behaviour of water and one or two substances is a remarkable exception to the general law, that bodies expand when heated, and contract when cooled. If water at the ordinary temperature be cooled down, it contracts like other liquids until it reaches a temperature of 39° Fahr.; it then begins to expand, till it reaches the freezing point, just before which it occupies as large a bulk as it did at 48°. The smallest bulk which water can be made to occupy is at 39°, and hence this point is called the maximum density of water. Between 32° and 39° water will therefore contract when heated, and expand when cooled. This anomaly in the case of water is a fact of the greatest importance. It is owing to this that the great bulk of the water of rivers and lakes is protected from a freezing temperature, which would be fatal to the animals contained in them. After the whole body of the water has reached a temperature of 39°, further cold lightens the superficial portions, which thus remain on the surface; and after a time this fact is rendered evident by a floating cover of ice.

The first reliable experiments on the *expansion of gases* by heat were made by Gay-Lussac, who arrived at a law that all gases and vapours expand alike for equal increments of heat. In passing from the freezing to the boiling point of water they increase in bulk more than one-third, or augment $\frac{1}{490}$ of their volume for every degree Fahrenheit. More recently the elaborate researches of Regnault have proved that Gay-Lussac's law is true only for the permanent gases, the coefficient of expansion of which is 0·00366, or $\frac{1}{273}$ of their volume, for every degree Centigrade, the condensible gases having a slightly greater coefficient than this. The large increment in bulk which gases undergo when heated has been made use of in many ways. The air thermometer [DIFFERENTIAL THERMOMETER] depends on this fact, and from the delicacy of its indications was constantly used in experiments on radiant heat, until replaced by the thermopile. The rise of fire balloons and of smoke in chimneys, winds and air currents, and the ventilation of rooms, depend on the greater bulk of heated air.

A point of great importance is connected with the expansion of gases by heat. When a gas is heated and allowed to expand freely under ordinary atmospheric pressure, its coefficient of expansion is nearly the same as that found by keeping the volume of the gas constant, and noting the additional pressure necessary to overcome the increased elasticity of the gas, which is augmented in proportion to the temperature. But the amount of heat required to raise the temperature of the gas a certain amount in the former case, when the *pressure* is kept constant, is more than that required in the latter, when the *volume* is kept constant. The exact proportion in the two cases is as 1 : 1·421. The explanation of this difference is to be found in the fact, that where the gas is free to expand under constant pressure, it lifts a weight, and therefore does an amount of work which is not accomplished when it is heated under constant volume. The additional heat absorbed is used solely to lift the weight; and this precise amount, if the pressure be unaltered, is again evolved when the gas contracts to its original volume. As, therefore, the excess of heat is employed in nothing but mechanical labour, it expresses the relationship between heat and work; and accordingly from this ratio it would be possible to deduce theoretically the mechanical value or equivalent of heat. The importance of this fact was clearly seen by a German philosopher named Mayer, who made a calculation of the mechanical equivalent shortly before Dr. Joule arrived at his experimental results. When error is avoided, the equivalent found in the two cases is practically the same.

If we regard heat as a vibratory motion of the particles of bodies, we arrive at a simple explanation of the effects of heat in causing expansion and change of state. The addition of heat causes more rapid and wider molecular vibration; for the particles of the coldest substances are not deprived of the motion of heat. This increased range of motion increases the distance between the particles, and expansion of the whole substance ensues. But as the particles recede from each other, the force of cohesion which holds them together becomes lessened according to known laws; the substance thus passes from the solid condition, in which cohesion is strongest, to the liquid state, in which it is far less. By further heating, the cohesion of the liquid can be entirely overcome, and the particles, now without any bond of union, fly asunder in the vaporous or gaseous form. When this occurs, ebullition or boiling of the liquid begins: with water the boiling point is 212° Fahr. when the barometer stands at 30 inches. Ebullition takes place when the heat has so increased the elasticity of the particles of the liquid, that the tension of the vapour which is formed is equal to the atmospheric pressure: the greater the pressure, therefore, the higher the boiling point, or vice versâ. When the vessel is heated at the bottom, the weight of the column of the liquid has to be added to the pressure of the air, so that the lower portion of water heated in long tubes or in large masses rises considerably above 212°, and the boiling is irregular and explosive.

While a substance remains in one state of aggregation, the heat imparted to it raises its temperature, as is evident by the sense of touch or by the rise of a thermometer. But in passing from the solid to the liquid, or from the liquid to the vaporous condition, the heat

absorbed by the substance during this time is insensible to the touch or to the thermometer. If, for example, a block of ice be heated, a thermometer fixed within it rises until it reaches a temperature of 0° C. or 32° Fahr.; it then ceases to rise until the whole of the ice has been liquefied, after which it begins again to move and continues rising until it marks a temperature of 100° C. or 212° Fahr. Steam is now produced, and if the water be in an open vessel, the further application of heat causes no further change in the thermometer. When the first experimentalists saw that a large addition of heat to ice at 32°, or water at 212°, caused no change in the thermometer, they accounted for the heat that had disappeared by saying it had somehow become hidden or latent, and thus arose the term of *latent heat*. This unsatisfactory explanation has been removed by the dynamical theory, which assigns the heat that has become insensible to the performance of work in shifting the relative positions of the atoms. Heat in the so-called latent state is, in fact, heat consumed in mechanical motion, just as in a steam engine heat is consumed in causing a crane to lift a weight. And as when the lifted weight is allowed to fall, it generates in its fall the exact amount of heat actually spent in raising it, so the precise amount of heat absorbed by a body in order to change its state of aggregation is reproduced when it passes back to its original condition.

The heat necessary to liquefy a solid is called the *latent heat of liquidity* or *latent heat of fusion*, and the heat employed in changing a liquid into vapour is called the *latent heat of vaporisation*. In the case of water, the amount of heat necessary to cause ice at 32° to become water at 32° would raise the same weight of water 143° Fahr.; whilst to convert water into steam of the same temperature, 967° Fahr. are required. The former number is called the *latent heat of water*, the latter the *latent heat of steam*. But these numbers are not the same for all bodies; each substance has its own latent heat. The different amounts of heat required to liquefy and vaporise a few of the more important bodies are here given. The figures are taken from Miller's *Chemical Physics*, and express the temperature that an equal weight of water would be raised by the passage of each of the bodies enumerated, from the liquid to the solid, or from the vaporous to the liquid state.

Latent Heat of Liquefaction.

	F.		F.
Water	143°	Sulphur	17°
Zinc	51	Lead	10
Silver	38	Phosphorus	9
Tin	26	Mercury	5
Bismuth	23		

Latent Heat of Vaporisation.

	F.		F.
Water	967°	Bisulphide of carbon	156°
Alcohol	375	Oil of lemons	126
Acetic acid	183	Oil of turpentine	124
Ether	163	Iodine	43

When a solid is reduced to the liquid state by solution, heat is in like manner always absorbed, unless a chemical combination of the solid and liquid occur. The solution of salt or sugar in water thus chills the liquid. FREEZING MIXTURES can even be formed by the extreme cold which attends the liquefaction of many soluble salts. On the other hand, heat is evolved during solidification, so that in winter, when masses of water freeze, the severity of the cold is mitigated. The chilling caused by vaporisation explains many familiar facts. By the evaporation of eau-de-cologne or ether, a forehead moistened with the liquid is cooled; on the same principle water can be frozen and ice made in large quantities. It is also from the evaporation of the water which has percolated to the outside that porous earthenware vessels filled with water cool objects placed within them.

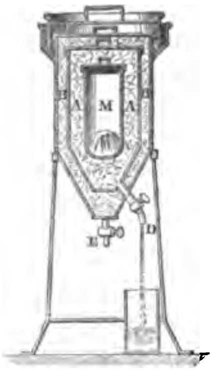
Having seen that heat when imparted to a body can be applied in two ways, either in raising its temperature or in changing its state of aggregation, and having ascertained that different solids and liquids require different quantities of heat to alter their condition, the question now arises, Do all substances whilst in one condition rise equally in temperature for equal increments of heat? They do not; and this difference, which is a special and important characteristic of all bodies, used to be termed the *capacity for heat*, but is now generally spoken of as the *specific heat* of a substance. By this term is meant the quantity of heat required to raise the temperature of any substance 1°, compared with that required to raise an equal weight of water 1°.

As different amounts of heat are expended in raising the temperature of different bodies to the same point, if various substances be taken at the same temperature they will not all contain the same quantity of heat; nor will they, if cooled down, yield equal amounts. Accordingly, when two liquids at different temperatures are mixed together, the resulting temperature will not be the mean of the two, if the liquids are of different specific heats. A pound of ice-cold water mixed with a pound of boiling water gives two pounds at the mean temperature, viz. $(32° + 212°) \div 2 = 122°$ (if ice at 32° be taken instead of water, the latent heat of water must, of course, be first subtracted from the hot water); but if equal weights of mercury at 32° and water at 212° be mixed, the resultant temperature will be about 206°; i. e. the water has lost only 6°, whilst the mercury has gained 174°. The specific heat of mercury is therefore about 30 times less than the specific heat of water.

Various means have been employed for determining the specific heat of a body; these, however, can be reduced to three different principles. The earliest and most liable to experimental error is founded on the melting of ice, and was used by Black, Lavoisier, and Laplace. This method consists in heating a given weight of the body up to some fixed temperature, say 212°, then plunging it in dry ice, and subsequently determining the amount of ice

which it melts in cooling down to 32°. The apparatus by which this is usually accomplished is known under the name of the *ice calorimeter*. A section of this instrument is annexed; the drawing is taken from Ganot's excellent treatise on elementary physics. The body the specific heat of which is to be determined, after having been weighed and heated for some time in an oil or water bath, is placed in the central compartment M. A lid is quickly placed over it and covered with pounded ice, which already fills the surrounding vessel A; over this again another lid is placed and covered with ice, which the outer concentric vessel B also contains; finally a double lid covers the whole. The vessel M is thin and a good conductor, so that the ice in A is quickly melted by the hot body M. The water thus produced flows out by the stopcock D, and is carefully collected and weighed. The ice in the outer vessel B cuts off the influence of the surrounding atmosphere, the water from any liquefaction that may occur escaping by the stopcock E. The latent heat of water being known, the specific heat of the substance can readily be calculated from the quantity of water which has been melted from the ice in A. Black used in his experiments a simple block of ice, in which a cavity was made to contain the heated body, and over which an ice cover was laid. After a time both substance and cavity were wiped dry with a cloth, the weight of which before and after was determined. This forms a ready and simple way of roughly estimating the specific heat of various bodies.

Fig. 1.



The second method of determining the specific heat of a substance is to note, under similar circumstances, the *rate of cooling* of different bodies the weight and temperature of which are equal. The last method is that of *mixtures*, an example of which (mercury and water) has already been given. In the case of a solid body determined by this method, the substance is weighed, raised to a known temperature, and then plunged in a known weight of water; from the rise in temperature of the water the specific heat of the solid is calculated. This method has been adopted by Regnault in a series of exhaustive and most refined experiments on the specific heats of solids, liquids, and gases. In examining liquids it is necessary to enclose them in a little vessel; and gases are caused to pass through a spiral tube surrounded with water, the alteration in temperature of which is observed. The following table gives some of Regnault's results on the specific heat of different solids, liquids, and gases, compared with an equal weight of water taken as unity.

Specific Heat of Solids.

Lithium	0·941	Zinc	0·095
Ice	0·474	Copper	0·095
Sodium	0·293	Brass	0·094
Wood charcoal	0·241	Silver	0·057
Sulphur	0·203	Tin	0·056
Glass	0·198	Gold	0·032
Diamond	0·147	Platinum	0·032
Iron	0·114	Lead	0·031

Specific Heat of Liquids.

Water	1·000	Turpentine	0·426
Alcohol	0·637	Bisulphide of carbon	0·235
Ether	0·528	Mercury	0·033
Benzol	0·436		

Specific Heat of Gases.

Hydrogen	3·409	Nitrogen	0·244
Marsh gas	0·593	Air	0·237
Ammonia	0·508	Oxygen	0·218
Aqueous vapour	0·481	Carbonic acid	0·216
Olefiant gas	0·404	Chlorine	0·121
Carbonic oxide	0·245		

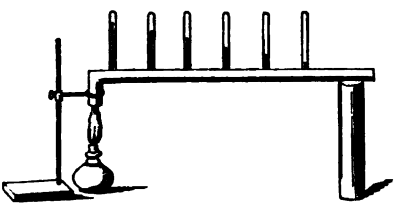
Of all solids and liquids, water has the highest specific heat; this, which is one among the many singular and wonderful properties of water, is an important fact, and one of the highest value, especially in the influence which large masses of water must exert in moderating extremes of climate. A substance in the liquid state has a higher specific heat than the same body when solid, but it is lower in the gaseous than in the liquid condition. Temperature increases the specific heat of a substance: for example, the specific heat of water at 32° is 1·000, whilst at 212° it is 1·013. Dulong and Petit discovered a relationship between the specific heat of an element and its weight, and established a law, which bears their name, that the specific heat of an elementary body is *inversely* as its atomic weight; consequently the product of the specific heat of an element into its atomic weight gives, with but slight variations, a constant number or a multiple of that number. This product is known by the name of the *atomic heat* of a body, or the quantity of heat necessary to raise the temperature of the same number of atoms one degree. As this is a nearly constant quantity, 'all elementary atoms, great or small, light or heavy, when at the same temperature, must possess the same amount of the energy called heat, the lighter atoms making good by velocity what they want in mass.' Regnault, in his researches, has confirmed Dulong and Petit's law, and extended it to compound bodies.

Thus far the effects of heat upon different bodies have been examined: it now remains only to state the manner in which heat is propagated, a process constantly taking place in order to restore or preserve that equilibrium of temperature spoken of under the article Radiation. This propagation of heat is carried on in three ways. If a solid body be heated at one end, the motion of heat thus imparted is communicated from one molecule of the body to that next adjacent, and this to the next, and so on, until the heat, passing from

particle to particle, has slowly reached the utmost limits of the solid, the intensity rapidly diminishing as the distance from the heated point increases. This process of transmission is termed *conduction*. Amongst liquids and gases, the transfer of heat is accomplished not by a molecular movement of this kind, but by the motion of sensible masses from place to place. When a liquid or gaseous column is heated at the bottom, the part warmed expands, and becomes lighter than the mass above; it consequently rises, and is replaced by colder and denser portions: ascending hot currents and descending cold currents are thus produced, and by a circulation of this kind the whole mass is heated. Distribution of heat by this means is called *convection*. Finally, the heat of a warm body is propagated, not only by conduction to contiguous particles, or by convection through limited masses, but is carried to an unlimited distance by radiation. It is here that heat so closely resembles light, being propagated in the same manner and obeying the same laws. [RADIANT HEAT.]

Returning to the conduction of heat, we find that all bodies do not possess this power equally. Some, like the metals, which also differ among themselves, can transmit the molecular motion of heat with considerable ease; these are therefore termed *good conductors*. Others, like glass, wood, and all organic substances, impede this motion, and are called *bad conductors*. Liquids, and more especially gases, communicate this motion among their particles so slowly that they may practically be regarded as non-conductors. Ingenhausz, Despretz, Wiedemann and Franz, and Calvert and Johnson, have determined the conductivity of various substances. The means employed by Despretz is represented essentially in fig. 2. In a bar of the substance to be tried, holes are drilled at equal intervals; in these cavities mercury is poured, and a delicate thermometer is placed in each of them. The bar is heated at one end, the thermometers slowly rise one after the other, until, after a sufficient time has elapsed, they cease to move, indicating a fixed temperature, which is less the farther they are removed

Fig. 2.



from the source of heat. The worse the conductor, the greater the difference between any two successive thermometers. A more recent and complete investigation has been made by Wiedemann and Franz, who employed the same method, substituting, however, thermo-electric couples for the thermometers. From the results of these experimenters the following table is derived; the best conductor, silver, being represented by 100, copper will be 74.

Conductivity of Solids.

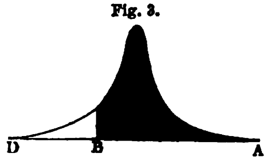
Silver	100	Iron	12
Copper	74	Lead	9
Gold	53	Platinum	8
Brass	24	German silver	6
Tin	15	Bismuth	2

It has been found that the order of conductivity in this table is also the order in which the same bodies conduct electricity: a remarkable and interesting relationship is thus established between these two forces. Bodies which are not homogeneous do not conduct heat equally in every direction; this was discovered and shown to be the case with crystals by De Senarmont, and with wood by De la Rive and De Candolle, a fact confirmed and extended by Tyndall.

It is owing to the different conducting power of bodies, that various substances at the same temperature feel unequally hot or cold. The use of kettle-holders and wooden handles is to protect the hand from the heated metal by the interposition of a bad conductor. For the same reason our clothes keep us warm by preventing the loss of bodily heat; the worse the conductor, therefore, the warmer the garment. Engineers also use this principle when they surround the boilers of steam engines with a jacket of some bad conducting substance. The cracking of glasses and jugs by suddenly pouring hot water within them, whilst metal vessels are not thus broken, is another result flowing from differences in conductivity.

Considerable light has been thrown upon the molecular changes which a body undergoes when being heated, by the investigations of Draper in America. This philosopher watched through a prism the changes in the radiation emitted from a body gradually raised from an obscure to a white heat. When any cool body, a poker, for example, is heated in the fire, the rays first emitted by it are entirely invisible or obscure. Beginning with

Fig. 3.



the emission of rays of low refrangibility, represented by the curve at the right-hand end of the diagram (A, fig. 3), the radiation from the poker, as it is more highly heated, gradually increases in intensity, until at last (B) it becomes incandescent; retaining all the rays previously emitted, it now sends forth in addition waves of red light, to which presently are added orange, then yellow, then green, then blue, indigo, and violet, and when all the colours of the spectrum are present, it glows

with a white heat, giving the spectrum of thermal intensity, A B D. It is probable that after this point has been reached, if the substance be sufficiently refractory to allow of still increased heating, it will give out with increasing intensity the rays beyond the violet, until the glowing body can rapidly act in forming chemical combinations, processes which require rays of the highest refrangibility, the so-called actinic or ultra-violet rays. These are the changes which occur in heated solids or liquids; but with gases the case is different, for no gas or vapour, however much heated, has yet been found to emit luminous rays.

For further information, and a lucid application of the dynamical theory to the various phenomena of heat, the reader may consult Tyndall's excellent treatise on *Heat as a Mode of Motion*, and Stewart's concise manual on *Heat*.

Theseus (Gr. Θησεύς). The rationalistic process by which Herodotus (i. 1–5) extracted a prosaic and perfectly plausible narrative out of the impossible myths of Io, MEDEIA, and HELEN, enabled Thucydides (ii. 15) to frame for the age of the mythical Theseus a political history which may certainly be true, but for which we have not the faintest evidence. According to the great Athenian historian, Theseus was the far-sighted statesman who, seeing the evils of isolation, deprived the Attic demi of their absolute autonomy, and bound them together in a confederacy in which Athens became the seat of a single commonwealth. Over this state he ruled not as a despot, but as a constitutional sovereign, strictly confining himself to his definite functions.

This plausible fiction has been extracted from the stories of the older mythographers, who spoke not of a sagacious political leader consulting the best interests of his people, but of a son of POSEIDON (or Ægeus, king of Athens) and of Æthra (*the pure air*), who grew up in the house of Pittheus, king of Trœzen, under the care of his mother, who told him that a great work lay before him so soon as he could lift the stone beneath which lay his father's sword and sandals. Thus, in due time gaining possession of the invincible weapon, as Sigmund, in the tale of SIGURDR, obtained the good sword Gram, Theseus started on that career of conquest the incidents of which present the closest parallel to those of Perseus, Bellerophon, Meleagros, Œdipus, and, most of all, of Heracles, of whom he is in every respect the counterpart. Like him, he is a destroyer of noxious beasts, the avenger of the oppressed, and the terror of evil-doers. Having smitten PROCRUSTES and a horde of lawless marauders, he reaches Athens, where, according to one version, Medeia recognised and sought to poison him. With the sword as the token of his birth, he appeared before Ægeus, who acknowledged him as his heir. In the chase of the Marathonian bull which followed not long after, Androgeos, son of MINOS, met his death; and the levy of the tribute children was imposed on the Athenians by the Cretan king. Voluntarily offering himself to join the doomed band, Theseus went to Crete, where ARIADNE gave him a sword wherewith to slay the MINOTAUR, and a clue by which he might extricate himself from the labyrinth. On his homeward voyage Ariadne accompanied him, but being deserted by him in Naxos, she became afterwards the bride of DIONYSUS. As the ship of Theseus drew near to the Peiræeus, he forgot to hoist the white sail which he had promised to raise as the signal of safety, and thus, like Perseus and Œdipus, Theseus becomes the cause of his father's death. Among the later exploits of Theseus was his war with the AMAZONS, who are said to have invaded Attica, and to have been defeated by him in Athens itself. He is also one of the heroes in the Argonautic voyage [MYSTERIES], in the Calydonian hunt, and in the war against Thebes. Aided by Peirithous and the Lapithæ, he fought against the CENTAURS, and with the help of the former he carried away Helen from Sparta. In return for this kindness, he took part in the attempt of Peirithous to steal PERSEPHONE from Hades, and when Peirithous had fallen, he himself underwent a captivity from which he was at length delivered by Heracles. But his life, like that of Perseus and Œdipus, closes in gloom. Enemies plot against him, and he withdraws to Skyros, where he is treacherously slain.

According to some traditions, Theseus not only carried away Helen, but became by her the father of Iphigeneia, whom Clytæmnestra brought up only as her foster child, and who, according to the Æschylean version, was sacrificed by Agamemnon at Aulis to avert the wrath of Artemis. In other tales, a meaner victim is substituted in her place, and Iphigeneia becomes a priestess of Artemis in Tauris, famed for its human sacrifices; in others, again, Iphigeneia is identified with Artemis herself. Athenian legends represented her as carrying the statue of Artemis to Brauron near Marathon, where she is said to have died. As a daughter of Theseus, she was connected with the heroic families of Attica, where human sacrifices were offered to her, if we may draw this inference from the custom, in historical days, of shedding some human blood in the worship instituted in honour of Orestes.

Thus, like Phœbus, Apollo, and Perseus, like Heracles, Achilleus, Odysseus, and Bellerophon, Theseus carries an invincible weapon, which none else has the strength to wield; like them and other solar heroes, he is a slayer of monsters, which answer to Python and Fafnir, to Belleros and the Sphinx, to the Chimæra and the Libyan dragon. Like Apollo and Heracles he undergoes captivity; and again, like Œdipus and Perseus, he becomes unwittingly the slayer of his father.

Thus the great dynastic legend of Athens exhibits the closest parallelism to the dynastic legends of Thebes and Argos. They are all, in short, versions of the same story.

differing only in names and in points of petty detail. Of this close agreement, the Athenians, Thebans, and Argives were doubtless profoundly unconscious; and their unconsciousness is the strongest evidence that these myths sprang up spontaneously on the soil of each country from phrases which denoted originally sights and sounds in the outward world. The story of Theseus is the story not only of other Hellenic heroes, but of Rustem, Feridoun, and Sigurdr.

Thesis (Gr. θέσις, *a position*). In a general sense, this word is applied to denote any proposition, affirmative or negative, which is laid down or advanced to be supported by argument; but it is more particularly applied to those questions which are propounded in most of the Scotch and the continental universities to the students previously to their obtaining a degree.

THESIS. In Music, the depression of the hand in marking or beating time.

Thesmophoria (Gr. θεσμοφόρια). A festival in honour of Demeter, surnamed the *lawgiver* (θεσμοφόρος). It was celebrated by many cities of Greece, but with most ceremony by the Athenians. [TRIPTOLEMUS.]

Thesmothetæ. [ARCHON.]

Thespesia (Gr. θεσπέσιος, *marvellous*). A small genus of *Malvaceæ*, consisting of entire-leaved tropical trees. *T. populnea*, the best-known species, is very common on the sea-shores of most eastern tropical countries, and also in Western Africa, the West Indies, South America, and the Pacific Islands. It grows to a height of forty or fifty feet; and from its dense head of foliage, it is in some countries called the Umbrella-tree. Several parts of the tree are applied to useful purposes. The inner bark of the young branches yields a tough fibre, fit for cordage, and used at Demerara for making coffee-bags, and the finer pieces of it for cigar envelopes. The wood is considered almost indestructible under water, and is therefore used for boat-building; its hardness and durability render it valuable for cabinet-making and building purposes, while in Ceylon it is employed for gun-stocks. The flower-buds and unripe fruits yield a viscid yellow juice, useful as a dye, and a thick deep red-coloured oil is expressed from the seeds.

Thespian Art. The art of tragedy or tragic acting is sometimes so termed, from Thespis, an Athenian, who lived in the first half of the sixth century before Christ, and introduced the first rudiments of a tragic stage. [DRAMA.]

Theta. The unlucky letter of the Greek alphabet, from its being the first letter of θάνατος, *death*. Hence the verse—

O multum ante alias infelix litera Theta.

Thetes (Gr. θῆτες). In ancient Attica, originally freemen who worked for hire. Under the constitution of Solon they formed the lowest class of free citizens, who contributed nothing to the support of the state. They served generally as light-armed soldiers, but sometimes also as regular infantry upon an emergency. (Boeckh, *Public Economy of Athens*, ii. 258; Grote, *History of Greece*, part ii. ch. xi.)

Thetis. In Greek Mythology, one of the Nereids, and wife of Peleus, king of Thessaly, by whom she became the mother of Achilles. [HOMERIC POEMS; ILIAD; MYRMIDONS; ODYSSEY.] It was at the marriage feast of Peleus and Thetis that ERIS threw on the table the golden apple, for which HERA, APHRODITE, and Athênê [MINERVA] appeared as claimants before PARIS.

Thick Strakes. In Shipbuilding, strakes of planking thicker than those used elsewhere. They are bolted on over the points of junction of the several pieces which compose the ribs or timbers.

Thicket (from *thick*). In Forestry, trees or shrubs crowded together in such a manner as to form a mass not easily penetrated by men or cattle.

Thickstuff. In Shipbuilding, this word denotes all plank above four inches in thickness.

Thierschite. A native oxalate of lime, forming a thin incrustation on the marble of the Parthenon at Athens.

Thieves' Vinegar. This useless preparation, which is also called *Marseilles vinegar*, and *Vinaigre des quatre voleurs*, is made by digesting rosemary tops, sage leaves, lavender flowers, and cloves, in vinegar: it was once regarded as an effective antidote against the plague and other contagious diseases.

Thin Out. Geologists say that strata *thin out* when they gradually diminish in thickness and disappear.

Thing or **Ting.** In the ancient Swedish (Suio-Gothic) and cognate languages, a judicial or legislative assembly. [ECCLESIA; PARLIAMENT.] The origin of the word is obscure. The *thingvalla* in Iceland was a spot in the southern part of the island where the *althing*, or general parliament, was accustomed in the middle ages to meet. (Ihre, *Glossarium Suio-Gothicum.*)

Thinning (from thin, Lat. tenuis). In Arboriculture, reducing the number of plants or trees which have been sown or planted, in order that those which are left may attain a more mature growth. Natural woods are also thinned for the same purpose. The operation ought to be commenced as soon as the extreme leaves or branches are nearly touching one another, and continue till the plants have attained their full growth, or the required dimensions or age. On no account should the branches of any one tree in a plantation be allowed to touch the branches of any other tree; because in that case the foliage is deprived of its due proportion of sun, air, and rain, and the tree is drawn up in height at the expense of its thickness and vigour to resist storms; while the timber or fruit produced will be diminished both in quantity and quality. There is no department of planting less understood than the subject of sheltering young plantations; and it may with truth be

said that in by far the greater number of cases nothing is ultimately gained by drawing up trees in masses, and afterwards thinning them out. The trees left being unprepared both by their bark and roots for the new atmospherical circumstances in which they are placed, receive a greater check than if they had been originally planted so thin as at no period of their growth to touch one another. The same rules apply to agricultural and horticultural crops.

Thiosaurite. A white or greyish variety of Anorthite found at the Plain of Thiorsa in Iceland.

Third (Lat. tertius, Ger. dritte). An interval in the musical scale, which may be either major or minor, the former containing four, the latter three semitones.

Third Order. In Ecclesiastical History, most of the chief religious orders have or had bodies of secular associates, not bound by vows, but conforming to a certain extent to the general designs of the order; a custom which, in the opinion of some, originated about A.D. 1476, when Sixtus IV. gave permission to the Carmelites to attach such persons to their body. In course of time the third order contained a mixture of secular and religious persons. [ORDERS, RELIGIOUS.]

Thirst (Ger. durst). The sensation of a desire to drink, consisting in a sense of dryness and heat of the mouth, sometimes extending along the œsophagus to the stomach. In cases of intense thirst, unrelieved by swallowing fluid, the posterior fauces become red, and the usual mucous secretion, as well as the saliva, becomes thick and viscid. A vague inquietude, troubled mind, and quick pulse ensue, and respiration becomes laborious. Some people soon suffer from thirst, and are in the habit of drinking to an excessive extent, while others hardly ever experience the sensation. Thirst is a common symptom of febrile and other diseases, such as diabetes both in the mellitic and in the insipid form. Excessive exercise or perspiration are common causes of thirst, in which case the sensation seems merely to announce the deficiency of water in the system. Habitual thirst is often acquired by indulgence in drinking, especially among labourers and others who take large quantities of beer, and who at length can scarcely exist without unnecessary and hurtful quantities of that or similar beverages. The thirst induced by exercise in warm weather is in ordinary cases most effectually relieved by milk and water, or tea.

Thirty Years' War. In History, properly a series of wars carried on between the Protestant and Roman Catholic leagues in Germany, in the first half of the seventeenth century. The house of Austria was throughout at the head of the latter party. The Protestant princes of Germany were assisted by various foreign powers; in the earlier part of the war by Denmark and Sweden, and afterwards by France. It is considered to have commenced with the insurrection of the Bohemians in 1618, and it ended with the peace of Westphalia in 1648. The history (incomplete) of this war, by Schiller, is rather a spirited historical essay than an accurate narrative.

Thirty-twos. In Printing, a sheet of paper which when printed folds up into thirty-two leaves or sixty-four pages. The book is called a 32mo.

Thistle. A general name for various plants, mostly belonging to the Composite family, though not confined to it. It is the popular name for the plants referred to the genus *Carduus*, one species of which, *C. lanceolatus*, is the plant which is most generally regarded as the Scottish national emblem, though a distinct plant, the *Onopordon Acanthum*, is sometimes so considered. The Holy or Milk Thistle is *Silybum marianum*; the Blessed Thistle is *Cnicus benedictus*; the Sow Thistle is the name of the genus *Sonchus*. A totally different genus of plants, of the Cactus family, viz. *Cereus*, is called Torch Thistle, and another member of the same family, *Melocactus*, is the Melon Thistle. Thistles are principally to be regarded as weeds.

Thistle of Saint Andrew. A Scottish order of knighthood, said to be of great antiquity, but revived by James V. in 1540; again by James II. of England, VII. of Scotland, in 1687; and a third time in 1703, by Queen Anne, who increased the number of knights to twelve, and placed the order on a permanent footing. The thistle, as is well known, is the national emblem of Scotland; the appropriate national motto, which is also the motto of the order, being, 'Nemo me impune lacesset' (*No one shall provoke me with impunity*).

Thitsee. *Melanorrhœa usitatissima*, the Varnish-tree of Burmah.

Thmei. An Egyptian goddess, frequently represented in Egyptian sculptures in the hands of the kings. The Hebrew Thummim (the Urim and Thummim, Exod. xxxix. 8, 10) is the plural or dual of the same word. (Wilkinson's *Manners and Customs of the Ancient Egyptians*, vol. v. p. 58.)

Tholes (A.-Sax. thol). The pins forming the *rowlocks* in the gunwale of a boat. If there be two to each rowlock, the oar is worked between them; if but one, the oar is fastened to it by a strap, or the thole passes through a hole in the oar.

Tholus (Gr. θόλος). In Architecture, a building of a circular form. The word is used by Vitruvius to signify the roof of a circular building. It was also employed to denote the laconicum of a bath, which was circular in form.

Thomæans or **Thomites.** In Ecclesiastical History, a name given in Europe to the ancient church of Christians established on the Malabar coast of India, and said to have been originally founded by St. Thomas. The language used by them in their sacred rites, when they were first discovered by Europeans, was the Chaldee or Syriac. The Portuguese have effected a partial conversion of them to the Roman Catholic Church.

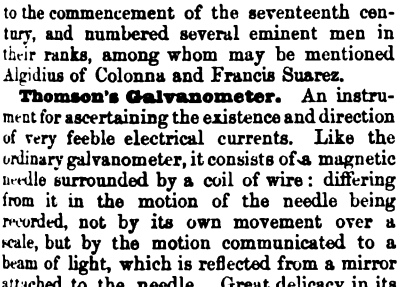
Thomäite. A prismatic form of carbonate of iron from the Siebengebirge, named after Professor Thomä.

Thomists. The followers of Thomas Aquinas, the Angelic Doctor, one of the most distinguished of the schoolmen of the thirteenth century. They differed from the rival sects of Scotists chiefly in the milder form under which they adopted the doctrines of realism. The Scotists regarded the universal as objectively and independently real; the Thomists sought rather to ground the objective in a spiritual or rational principle, in some degree approximating to the Platonic doctrine of ideas. The Thomists continued as a sect to the commencement of the seventeenth century, and numbered several eminent men in their ranks, among whom may be mentioned Ægidius of Colonna and Francis Suarez.

Thomson's Galvanometer. An instrument for ascertaining the existence and direction of very feeble electrical currents. Like the ordinary galvanometer, it consists of a magnetic needle surrounded by a coil of wire: differing from it in the motion of the needle being recorded, not by its own movement over a scale, but by the motion communicated to a beam of light, which is reflected from a mirror attached to the needle. Great delicacy in its indications can thus be attained. Instruments of this kind are in general termed *reflecting galvanometers*, but the one invented by Sir William Thomson has some special peculiarities which will be briefly described.

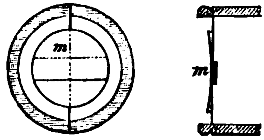
The instrument is represented at G M *b* in the accompanying drawing, for which we are indebted to Mr. Becker, of the firm of Messrs. Elliot Brothers, the makers of these instruments.

Fig. 1.



Several hundred coils of fine copper wire, made into a bobbin *b*, surround the circular aperture seen in the centre of the instrument. Within this aperture is suspended a tiny magnet, to which is attached an extremely light circular mirror *m* (fig. 2), about the size of a threepenny-piece. The light from a paraffin lamp, after passing through a slit in the lower part of the instrument seen at the right of fig. 1, falls upon the mirror, and is thence reflected to the graduated scale S, upon which it throws a line of light. The direction of the beam is indicated by the dotted lines. The image on the scale is made distinct by having the mirror ground slightly concave: this is shown in the section of the mirror and magnet, *m*, at the right of fig. 2. Now, the slightest motion of the magnet within the coil will cause twice the angular motion of the reflected ray; and as the scale can be placed at any distance from the mirror, the length of the luminous index can be proportionately increased, and thus an inappreciable deviation of the mirror can be indefinitely augmented. The sensitiveness of the galvanometer is still further increased by the use of the curved magnet M (fig. 1), which,

Fig. 2.



like the second needle in an astatic arrangement, is employed to neutralise the directive action of the earth upon the needle within the coil. The position of the poles, and the distance of this large magnet with respect to the needle, can be adjusted when necessary. This form of the reflecting galvanometer is of great value as an instrument for scientific research, and is exclusively employed for signalling through the Atlantic telegraph lines. [Telegraph, Submarine.]

Thomsonite. A hydrated silicate of alumina, lime, and soda, found in the basalt of Aberdeenshire, at the Kilpatrick hills, at the Giant's Causeway in Ireland, &c., generally in radiating masses of small prismatic crystals. Named after Prof. Thomson, of Glasgow, the discoverer.

Thoorgum. [Tycoon.]

Thor. In Teutonic Mythology, a son of Odin, the supreme god, and Freya his wife. He is a brother of Baldr, the glorious but short-lived hero, who in his life and death represents Achilleus, Rustem, and other solar heroes. Like Heracles, Thor journeys over sea and land, irresistible in his strength. He wears a strength belt, while his hands are sheathed in iron gloves, and his hammer splits the skulls of the giants and their kindred. Thor and the other children of Odin form the company of the Æsir, who are to reign until the twilight of the gods has come. This idea is seen in the Æschylean version of the legend of Prometheus, which asserts that the reign of Zeus and his partisans is one day to come to an end.

Thor, as the wielder of the hammer, or the smasher, is called, in northern mythology, Thor Miölnir, from the root *mar*, to crush, *grind*, or pound. [Language.] This name reappears in that of the Greek giants, Moliones, 'the sons of Molionê (*the mill*), and Aktor (*the corn-man*),' and again in that of the Aloadæ, Otos and Ephialtes, this name standing to Moliones in the relation of μόσχος to ὄσχος, *a branch* or *shoot*, and of ἄλευρον,

corn, to μάλευρον, a form mentioned by Helladius. To this same root belong apparently MARS, ARES, and the Sanscrit Maruts, or *the storms*. (Max Müller, *Lectures on Language*, 2nd series, vii.)

Thora. [SIGURDR.]

Thoracic Duct. The great trunk which conveys the contents of the lacteals and absorbents into the blood. In the human body it is about the diameter of a crow-quill, and lies upon the dorsal vertebræ between the aorta and azygos vein, extending from the posterior opening of the diaphragm, in a somewhat serpentine course, to the angle formed by the union of the left subclavian and jugular veins, into which it pours its contents. [CHYLE; LYMPH.]

Thoracics (Gr. θώραξ, *the chest*). The name given by Linnæus to those fishes which have the ventral fins placed beneath the pectorals.

Thorax (Gr.). The second segment of insects is so called by Latreille and Andouin; the term is restricted to the upper surface of the trunk by Linné and Fabricius. In Arachnidans the thorax and head are confluent, and form but one segment, which is termed the *cephalothorax*. As a cavity appropriated to the reception of the circulating and respiratory organs, the thorax is distinct only in Mammals.

THORAX. In Anthropotomy, the chest; the part of the body between the neck and the abdomen. It contains the heart and lungs, the œsophagus, the thymus gland, the thoracic duct, part of the aorta and vena cava, the vena azygos, the eighth pair of nerves, and a part of the great intercostal nerves.

THORAX. In Grecian Antiquities, a piece of defensive armour consisting of two parts, one defending the back, and the other the belly; called *lorica* by the Romans. The more ancient were made of padded linen; but they were also made of leather, brass, iron, and other metals.

Thoria or **Thorina** (from Thor, the Scandinavian deity). An earthy substance discovered, in 1828, by Berzelius in a rare Norwegian mineral called *thorite*, which is a hydrated silicate of thorina. Like the other earths, thorina is the oxide of a heavy grey metal, which has been termed *thorium*, and which is not acted upon by water, but when heated in the air it burns with great brilliancy into a white oxide. Thorina is white, infusible, and very heavy, its specific gravity being 9·4. It is insoluble in all acids except sulphuric, and in that with difficulty. Its equivalent is about 68. Thorina is distinguished from alumina and glucina by its insolubility in caustic potash, and from zirconia by being precipitated by ferrocyanide of potassium.

Thorite. Native hydrated silicate of thoria, found in the syenite of Lövön, near Brevig in Norway, in black, reddish-brown, or orange-yellow prismatic crystals. [ORANGITE.]

The metal thorium was first discovered in this mineral by Berzelius.

Thorn. A common name applied to various kinds of plants, which are furnished with thorns or spines. In this country it is especially applied to the *Cratægus Oxyacantha*, also known as the whitethorn, hawthorn, or quick, and so familiar as a hedge plant. The Blackthorn is *Prunus spinosa*; the Buckthorn, *Rhamnus*; the Camel's-thorn, *Alhagi Camelorum*; the Christ's Thorn, *Paliurus aculeatus*; and the Willow-thorn, *Hippophaë rhamnoides*.

Thorn Apple. [DATURA.]

Thornback. The name of a species of ray (*Raia clavata*, Linn.), distinguished by the short and strong recurved spines, rising from a broad osseous tubercular base, which are scattered over the back and tail. Two of these broad-based spines occupy the central ridge of the nose.

Thorough Bass. In Music, this expression is often used, though very objectionably, as synonymous with the science of harmony. In former times it was customary to consider the bass part as the principal element of the composition, to carry it completely *throughout* the piece, and to indicate the harmony by figures and signs placed above or below the bass notes; and the study of this *thorough bass* (*basso continuo*, or *general bass*, as it has been called) has hence come to be synonymous with the study of harmony generally.

Thoth, Thouth, Taout. An Egyptian divinity. His hieroglyphic represents the beginning of the astronomical year. He was regarded as the inventor of writing and Egyptian philosophy, and is represented as a human figure with the head of a lamb or ibis. (Plato, *Phædrus*; Plutarch, *De Is. et Osir.*; Wilkinson, *Ancient Egyptians*, vol. v.)

Thousand and One Nights. More commonly called among ourselves the *Arabian Nights' Entertainments*, from the title adopted in our first translation from Galland's version. A well-known collection of Oriental tales, which has acquired in the West a popularity never attained by any other Eastern composition. The history of the work has been the subject of much investigation, especially by De Sacy, Von Hammer, and Lane. According to Lane, the work, in its present form, is the composition of a single author living in Egypt, and was most probably 'not commenced earlier than the last quarter of the fifteenth century of our era, and completed before the termination of the first quarter of the next century, soon after the conquest of Egypt by the Osmanlee Turks in 1517.' But the origin of the tales is a much more difficult subject of enquiry. It seems to be now established (from the discoveries of De Sacy and Von Hammer) that there was an ancient Persian collection of stories, known by the name of the *Hezar Afzáneh* (the *Thousand Fanciful Tales*), of unknown antiquity, but certainly older than the ninth century of our era; that the framework of this collection was the same with that of the modern, viz. the story of the cruel king Shakryar and his ingenious queen Chehrazád; and that this was very

early translated into Arabic by the name of the *Thousand Nights*. But Mr. Lane differs from these learned Orientalists in still believing that the early work was only a model; that the greater proportion of the modern tales are really Arabian, especially all those founded on the supposed adventures of the Khalif Haroun and his queen Zobeyde, a few being only distinctly of Persian or Indian original; e.g. the *Magic Horse*, the *Damsel and the Seven Wezeers*. (De Sacy's Dissertation, prefixed to a late edition of Galland's version; Von Hammer's preface to that of Trébutien; Mr. Lane's Preface, and *Review* at the conclusion of his third volume.)

The *Arabian Nights* exhibit many features which are also seen in the mythology of Aryan nations, and for which no hypothesis of direct borrowing can account. Thus, the voyages of Sindbad contain some striking incidents in the legend of the Messenian hero Aristomenes, and Sindbad himself bears a strong likeness to Proteus and the Assyrian Oannes or Onnes. The tale of 'Ali Baba and the Forty Thieves' exhibits in some points a close correspondence with the story of Rhampsinitus (Herod. ii.), while, as a whole, it is identical with the tale entitled Simeli-Mountain, in Grimm's *Kinder- und Haus-Mährchen*. Tales in which magic carpets, invisible caps, tents capable of being rolled up into a hand's breadth and of containing a vast crowd, are common to the *Arabian Nights* fiction with the legends not only of Saracenic Spain, but of Germany and Iceland.

Thraêtana. In the Zend Mythology, a hero, who slays the biting serpent, Aji or Azi-dahaka, as Apollo slays PYTHON, and SIGURDR slays Fafnir. This Thraêtana of the Avesta is the Trita or Traitana of the Vedas, a name which reappears in Tritogeneia, an epithet of Athena. [MINERVA.] In the Trita, Yama, and Krisasva of the Veda we have the prototypes of Yima-Kshaêta, Thraêtana, and Keresaspa of the Avesta, the representatives of three of the earliest generations of mankind, just as the Germans spoke of the Ingævones, Herminones, and Iscævones as sprung from Mannus son of Tuisco (Tyr). These three names reappear in those of the three famous heroes of later Persian epic poetry, Jemshid, Feridún, and Garshasp. Of these, Feridún is the slayer of the tyrant Zohak, who is at once identified with Azi-dahaka, the biting serpent, the Ahi or throttling snake of Vedic mythology. As the slayer of his enemy Vritra, Indra is called Vritrahan, a name which (Vritra in the Zend being converted into Verethra) became Verethragna, and through the intermediate Pehlevi form *Phredun*, passed into the modern Persian Feridún. It has further been shown by Eugène Burnouf, that as in Sanscrit the father of Yama is Vivasvat, the father of Yima in the Avesta is Vivanghvat, and that the father of the Vedic Trita is Aptya, while the father of Thraêtana is Athwya. (Max Müller, *Lectures on Language*, second series, xi.; Bréal, *Hercule et Cacus* 130 &c.)

Thranite (Gr. θρανίτης, from θρᾶνος, *a bench*). The uppermost (or, according to some arrangements of the classical galley, the foremost) of the three classes of rowers in an Athenian trireme; the middle being called the *zeugitæ*, the lowest *thalamitæ*. [GALLEY; TRIREME.]

Thrashing (A.-Sax. therscan, Ger. dreschen). Separating grain or seeds from the straw or haulm by means of a flail or thrashing machine, or by treading with cattle. The latter was the mode employed in ancient times; and it is still practised in the south of Europe, and in Persia and India. The Romans employed oxen for this purpose; sometimes alone, and sometimes with the addition of a kind of roller studded with iron knobs, which they dragged over the corn, and which was spread on a circular floor, the driver standing in the centre, and guiding the oxen around him by means of reins. It was customary to allow the oxen occasionally to breathe and take a bite of the corn, agreeably to the Levitical precept. A kind of flail or rod was also sometimes used by the Romans, and is doubtless the origin of the present implement of that name. In colder and moister climates, such as that of Britain, where a floor sufficiently hard for thrashing out corn could not be maintained in the open air, thrashing appears to have been always performed under cover, and with the flail, till the latter end of the eighteenth century, when thrashing machines were introduced.

Thrashing Machine. A machine for separating corn or other seeds from the straw or haulm; and either impelled by horse or cattle, wind, water, or steam. The modern thrashing machine was invented in Scotland about the year 1758 by a farmer in the parish of Dumblaine, Perthshire, and afterwards brought to nearly its present state of perfection by Mr. Meikle, a millwright of Haddingtonshire, about the year 1798. Meikle's thrashing machine consists of a cylinder furnished with beaters fixed on its circumference, to which the corn is presented by rollers, the ears being thus beaten in pieces; and while the grain drops through a grating into a winnowing machine, the straw is carried forward, and delivered by itself ready to be made up into bundles. Some thrashing machines only beat out the corn, and separate it from the straw; while others beat it out, winnow it, and sift it, and deliver it in bags fit for market.

The employment of thrashing machines relieves the labourers from the severest drudgery incident to agriculture; they enable the work to be done at the time when there is a demand for corn; and, by doing it better, or separating the corn (particularly wheat) more completely from the straw, they add both to the wealth of the farmer and the produce of the country; enabling the former to employ, and the latter to feed, more labourers. The latter is, indeed, a most important consideration. It is calculated, by the best informed agriculturists, that 5 per cent., or one twentieth part, more produce is afforded

by a crop thrashed by machinery than by the old method; and, estimating the total produce of the corn crops of Great Britain and Ireland at 50,000,000 quarters, we should, on this hypothesis, have an additional annual supply of no less than 2,500,000 quarters, if thrashing machines were universally substituted for flails. So great an increase of produce in the hands of the farmers would obviously enable them to employ far more labourers than would be superseded by the use of the machine.

All thrashing machines are now driven by steam, and the work in England is generally accomplished by travelling engines and machines, the services of which are hired by the farmer.

Thraulite (Gr. θραυλός, *frangible*). A hydrated silicate of iron (a variety of Hisingerite) which occurs, with Magnetic Pyrites, at Bodenmais in Bavaria. It has a resinous fracture, and is very brittle.

Threatening Letters. The sending or delivering of letters threatening to publish, &c. libels, or to kill anyone, or demanding of any person with menaces any money or other valuable thing, or accusing or threatening to accuse any person of certain crimes, or the like, is punishable by English Law with imprisonment (with or without whipping) or penal servitude. (Stats. 6 & 7 Vict. c. 96; 24 & 25 Vict. cc. 96, 100.)

Three Bodies, Problem of the. A dynamical problem, of considerable celebrity, interest, and difficulty, the object of which may be said to be the determination of the circumstances attending the motion of three bodies, which mutually attract one another. In Physical Astronomy, the problem has, obviously, important applications; and accordingly it is to treatises on astronomy, and especially to the *Mécanique Céleste* of Laplace, that the reader must be referred for further information.

Three Chapters. In Ecclesiastical History. Under this name, the emperor Justinian condemned certain works of Theodore of Mopsuestia, Theodoret of Cyrus, and Ibas of Edessa, as being infected with the Nestorian heresy. (Milman, *Latin Christianity*, book iii. ch. iv.) [NESTORIANS.]

Three, Rule of. [RULE OF THREE.]

Threnody (Gr. θρηνῳδία, from θρῆνος, *a dirge*, and ᾠδή, *song*). A short species of occasional poem, on the death of some distinguished personage. [EPICEDIUM.]

Thridace (Gr. θρίδαξ, *lettuce*). *Lettuce opium*, called also *Lactucarium*. It is the inspissated juice of the common lettuce, which is slightly sedative.

Thrinax (Gr. *a three-pronged fork*). A small genus of Fan Palms, chiefly West Indian, of which some six or eight species are known, all comparatively low growing, seldom exceeding twenty feet in height, and frequently not more than ten; having their trunks clothed with the persistent bases of old leaves or marked with circular scars, and bearing a crown of much-cut fan-shaped leaves. In Jamaica they are commonly known by the name of Thatch-palms, their leaves being used for thatching, for which some of them are admirably adapted. One of them, *T. argentea*, is said to yield the young unexpanded palm-leaves imported from the West Indies under the name of Palmetto Thatch, and extensively employed for making palm-chip hats, baskets, and other fancy articles; but it is more than probable that the leaves are gathered from several species, while in the United States those of the allied genus *Sabal* are substituted. The tough leaf-stalks are also split into strips and woven into serviceable baskets, and the head of the undeveloped leaves or cabbage forms an excellent vegetable. *T. argentea* is likewise a native of Panama, where it is called *Palma de escoba*. or Broom-palm, its leaves being there made into brooms.

Throat (A.-Sax. throta). In Botany, the opening or orifice of a monopetalous corolla.

THROAT. On Shipboard, the wide end of a gaff next the mast. The opposite end is the *peak*.

Thrombolite (Gr. θρόμβος, *a lump*, and λίθος). Native hydrated phosphate of copper. It occurs amorphous, of an opaque green colour which becomes black on exposure to the air, at Rezbanya in Hungary, on limestone.

Thrombus (Gr. θρόμβος). A small tumour, which sometimes ensues in consequence of the escape of blood into the cellular membrane in the operation of bleeding.

Throne (Gr. θρόνος). In Architecture, a chair of state raised above the level of the floor on which it stands, usually richly ornamented and covered with a canopy.

Thrush. In Medicine. This disease, so named from its speckled appearance like that of the bird, consists in the formation of small white ulcers upon the tongue, palate, and gums, and is common in infants who are ill-fed or brought up by hand. It is apt to extend through the whole course of the mucous membrane lining the alimentary canal, exciting fetid eructations and flatulency, with a troublesome diarrhœa, and sometimes proves fatal. It is, however, nearly always confined to the mouth.

THRUSH (A.-Sax. drise, Ger. drossel). In Ornithology, one of the largest and most melodious of our native song birds; the type of the genus *Turdus* (Linn.). It is not migratory, but is supposed to quit the more northern parts of England in winter for the southern provinces. It makes its nest in March; lays four or five blue eggs, spotted with black at the larger end. It feeds on berries, insects, and shell-snails; and often selects a particular kind of stone, against which it breaks the shell of the snail, and near which a great quantity of fragments of the shells may be found.

Thrust (Lat. trudo, *I push*). In Architecture, the horizontal force of an arch, by which it acts against the piers from which it springs. Also a similar action of rafters or of a beam against the walls which bear them.

Thug (from the Hindee verb thugna, *to deceive*). A member of a singular association of robbers and murderers, which has existed for many ages in India. It appears that the existence of the system of *thuggee*, as it is called, was hardly known before the year 1810, and that no combined measures were taken to put a stop to it until about 1830. Since that time it has been fully detected and greatly checked, chiefly through the admission of approvers from all the gangs. Captain Meadows Taylor stated in 1839, that between 1831 and 1837, 3,266 Thugs were brought to justice, of whom 412 were hanged, 1,059 transported, and 483 turned approvers. Its origin is unknown; and both Mohammedans and Hindus belonged to the society indifferently, although its tutelary goddess, Bhowanee, is a Hindu deity. The Thugs were directed in all their proceedings by auguries supposed to be vouchsafed by their goddess; and particular classes were altogether exempt from their attacks: among these were dancing girls, minstrels, sikhs, some religious mendicants, tailors, oilmen, blacksmiths, carpenters. It is stated that they seldom destroyed women unless for their own safety; and they very seldom ventured to attack Englishmen. They usually moved in large gangs, and attached themselves to travelling parties, with whom they would journey for days, until they found an opportunity for mastering them. When all was ready, one division of the murderers strangled the victims, while another body prepared their graves; and by means of this division of labour the fearful work was accomplished with wonderful celerity. It appears that numbers of Thugs resided together in villages, where they were protected by the landowners, and sometimes by rajahs, to whom they paid tribute. The destruction of life occasioned by them may be conjectured from the fact that one Thug, admitted an approver at Saugor, confessed to Col. Taylor, who does not seem to suspect him of exaggeration, that he had been concerned in the murder of 719 persons. The existence of so strange and monstrous a system can only be explained by the condition of India; the extreme timidity and apathy of its inhabitants, and their division into castes; the number of small native governments; the habit of dwelling in villages, divided by extensive uninhabited tracts; the frequency of travellers in that commercial country, which had no navigable rivers or secure conveyances; and the murderous spirit of Hindu fanaticism. In 1848, Sir W. Sleeman (who had done invaluable service towards their suppression) was of opinion that the 'old Thug associations were effectually put down.' But under the cognate form of 'dacoity,' robbery by armed bands long continued a common occurrence, and a special police was maintained for its suppression, until 1863, and is still continued in some native protected states, where the spirit of Thuggee is thought to survive. (See Sir W. Sleeman's *Ramasceana, Vocabulary of the Thugs*, and an article on it in the *Ed. Rev.* vol. lxiv.; and Col. Meadows Taylor's *Adventures of a Thug*, 2 vols. Lond. 1839.)

Thuja (Gr. θύος). One of the genera of the cupressineous division of *Coniferæ*, consisting of evergreen trees, natives of North America. One species is very common in English gardens under the name of Arbor Vitæ, the origin of which designation is uncertain. The branches are very numerous, the smaller ones arranged in two rows, and covered with small closely-pressed lozenge-shaped leaves arranged in four ranks. *T. occidentalis*, the American Arbor Vitæ, is a hardy evergreen shrub, everywhere pervaded with a powerful aromatic odour. The leaves have been used as a remedy for rheumatism, on account of their sudorific properties, and in America the wood is used for posts and other similar purposes. *T. orientalis*, the Chinese Arbor Vitæ, is sometimes separated under the name of *Biota*, on account of its roundish cones, more numerous scales, and wingless seeds. It is a native of Japan, China, &c., and is of a closer habit, with its branches directed more vertically upwards, and its leaves smaller and more densely packed than in the American species. This plant has a pungent aromatic odour; the young branches are said to be used for a yellow dye, and the wood is made use of where something is required to withstand humidity.

Thule. The name given by the ancients to some undefined part of the world, apparently to the north of Britain, as in the following lines of Seneca:—

> ——Venient annis
> Secula seris, quibus Oceanus
> Vincula rerum laxet, et ingens
> Pateat tellus, Typhisque novos
> Deteget Orbes, nec sit terris
> Ultima Thule.

On the connection of the inconsistent tales respecting Thule with the alleged commercial navigation of the Phœnicians, see Sir G. C. Lewis, *Astronomy of the Ancients*, p. 467 &c.

Thulite. A rose-coloured variety of Epidote, containing cerium, found in Norway at Sonland in Tellemarken, and lately discovered at Traversella in Piedmont. The name is derived from THULE.

Thumerstone. A Mineralogical name for Axinite, first found at Thum in Saxony.

Thummim. [THMEI; URIM.]

Thunder (Ger. donner, Lat. tonitru, from a root tan, *to stretch*, which is found in Gr. τείνω, Lat. tendo, Eng. *tone*, &c.). The noise produced by the passage of lightning through the air from one cloud to another, or from a cloud to the ground.

The character of the sound of thunder varies with the force and the distance of the explosion, the situation of the observer, and the nature of the surrounding country; and it is probably influenced also by the relative situations of the clouds.

When lightning strikes an object near us on the earth, it produces a noise resembling

that of a violent crash, which is not repeated or prolonged by reflection. When the explosion is more distant, a rumbling, irregular, and recurring noise is heard, which gradually dies away in the distance, like the prolonged echo of the sound of ordnance discharged in a mountainous district.

Thunder frequently commences with an astounding rattle, which is probably occasioned by a series of discharges of electric matter in rapid succession from a highly charged thunder cloud.

We have a familiar example of this species of noise in the cracking sound which accompanies the sparks discharged from the conductor of a well-supplied electrical machine towards any adjacent conducting body; the loudness of the snaps, as well as their frequency, increasing with the electric intensity. And when we consider how trifling a portion of electric matter can be put in action by the most powerful means of artificial excitement compared with the quantity stored up in a full-charged thunder cloud, the discrepancy between the appalling crash of the one and the insignificant snap of the other will not appear surprising, although both originate in the same cause.

This cause is the production of an air-wave by the sudden expansion of that portion of air which lies in the direct path of the electric discharge, and which becomes so intensely heated as to produce also the luminosity of lightning. This air-wave is propagated like other sound waves, and impinging upon the auditory nerves gives rise to the sensation of sound. The sound produced by the discharge of cannon is due to precisely the same cause, the only difference being that the air-wave is here produced by the sudden generation as well as expansion of gaseous matter. The continued roll of thunder is the effect of the comparatively slow propagation of sound through the air. For the sake of illustration, suppose a flash of lightning of 11,250 feet in length, or that the spark is instantaneously seen from one end to the other of this line. At the same instant the flash is visible the vibration is communicated to the atmosphere through the whole extent of the line. Now suppose an observer placed in the direction of the line of the flash, and at the distance of 1,125 feet from one end, then, since sound travels at the rate of about 1,125 feet in a second [SOUND], one second will elapse after the flash has been seen before any sound is heard. When the sound begins, the vibration communicated to the nearest stratum of air has reached his ear; and since we have supposed the line of disturbance to be 11,250 feet in length, the vibrations of the more distant strata will continue to reach his ear in succession during the space of ten seconds. Hence the length of the flash determines the duration of the sound; and it follows that the same flash will give rise to a sound of greater or less duration, according to the position of the observer with respect to its direction. Thus, in the above instance, suppose a second observer to be placed under the line, and towards its middle, he would only hear the sound during half the time it was heard by the first observer; and if we suppose the line to be circular, and the observer to be placed near its centre, the sound would arrive from every point at the same instant in a violent crash.

Thunder Dirt. The New Zealand name for the gelatinous volva of *Ileodictyon*, which is, or was formerly, eaten by the natives.

Thuringite. A hydrated silicate of alumina, and the protoxide and peroxide of iron, which occurs in the form of an aggregation of minute olive-green scales, at Schmiedfeld, near Saalfeld, in Thuringia; whence the name.

Thurls. Short communications between the adits in mines.

Thursday (A.-Sax. thunres-dæg). The fifth day of the week. The word contains the name of THOR, as Friday bears that of Freya.

Thus (Lat.; Gr. θύος). Frankincense, a resinous exudation from *Abies excelsa*.

Thwarts (Dutch dwars, Dan. tvers, Swed. tvars). The cross beams of an open boat, forming seats for the rowers and bracing the sides together.

Thylacinus (a word coined from the Gr. θύλαξ, *a pouch*, and κύων, *a dog*). A genus of carnivorous marsupials. The *Thylacinus* or *Peracyon cynocephalus* (zebra wolf of the Tasmanian colonists) is of the size and form of a wolf, but lower in the legs. It is transversely striped with black on a russet ground. In this genus the *ossa marsupialia* are wanting, being merely represented by fibro-cartilages in the external oblique muscles of the abdomen.

Thylacoleo (Gr. θύλαξ, and λέων, *a lion*). A genus of carnivorous marsupials, which existed during the pliocene period in Australia; its marsupial nature was demonstrated by the position of the lacrymal foramen in front of the orbit, by the palatal vacuity, the loose tympanic bone, the developement of the tympanic bulla in the alisphenoid, and the very small relative size of the brain. These characters distinguished it from the placental diphyodont carnivora, evidence of which in Australia has not been demonstrated during either geological or recent periods. The species *Thylacoleo carnifex* equalled the lion in size.

Thymeleaceæ (Thymelea, one of the genera). A natural order of shrubby perigynous Exogens, having a calyx only, and no corolla, although the flowers of many are coloured very gaily. The order is chiefly characterised by a tubular perianth, with four or five lobes, and bearing as many or twice as many stamens in its tube, and often small scales at the mouth; and by a simple ovary within the perianth-tube, with a short simple style, and a single pendulous ovule. *Daphnes*, valued for their fragrance, *Mezereum*, the various species of the Australian genus *Pimelea*, and the *Gnidias* and *Struthiolas* of the Cape of Good Hope, are favourite subjects of cultivation. One feature of the order is the causticity of the bark,

which acts upon the skin as a vesicatory, and causes excessive pain in the mouth if chewed. The berries of *Daphne Laureola* (the Spurge Laurel) are poisonous to all animals except birds.

Thymoyl. The product of oxidation of thymol: it contains $C_{24}H_{16}O_4$.

Thymoylol ($C_{24}H_{18}O_4$). An organic compound produced by the prolonged action of sulphurous acid on thymoyl.

Thymus (Lat.; Gr. θύμος, *thyme*). A genus of *Labiatæ*, widely dispersed over Europe, Northern Africa, and Central Asia, but most abundant in the Mediterranean region.

The Wild Thyme, *T. Serpyllum*, is common throughout temperate Europe and Asia, and Northern Africa. The common or Garden Thyme, *T. vulgaris*, which grows more erect than the Wild Thyme, is a native of Spain and Italy. Its uses are well known. The leaves, both in a green or dried state, are employed for seasoning soups, stews, sauces, and stuffings, to which they give an agreeable and highly aromatic flavour. In the South of France an essential oil distilled from it is imported into this country and sold as Marjoram oil, for which it is substituted. It yields a species of camphor by distillation with water, and in Spain they infuse it in the pickle with which they preserve their olives. The Romans were well acquainted with Thyme, which was one of the plants recommended to be grown for the sake of bees. The Lemon-scented Thyme is a hardy dwarf trailing evergreen, possessing the most agreeable perfume of any of its genus. It has long been cultivated in this country, and is used for the same purposes as the other species. It attains the greatest perfection when grown in dry light sandy soil.

Thymus Gland (Gr. θύμος). A gland situated under the upper part of the sternum, in the anterior mediastinum. It belongs to the class of ductless glands. It is of great comparative size in the fœtus.

Thynnus (Lat.; Gr. θύννος, *a tunny*). A genus of Scomberoid fishes, of which the highly valuable fish the tunny (*Thynnus vulgaris*, Cuv.) is the type. The form of the body in this genus of fishes is like that of the mackerel, but is less compressed; the first dorsal fin extends nearly to the second; the second dorsal and the anal fins are divided into numerous finlets: the sides of the tail are decidedly carinated; there is a single row of small pointed teeth in each jaw. The tunny is remarkable among fishes for its high temperature, its perfect respiratory organs, the quantity of nerves supplying the gills, and the general abundance of rich red blood throughout the body. It is the object of the most important fisheries in the Mediterranean Sea. The *bonito* (*Thynnus pelamys*) is a species of this genus of fishes.

Thyris (Gr. θυρίς, *a window*). A genus of butterflies.

Thyroid (Gr. θυροειδής, *like a door*). The thyroid or scutiform cartilage is placed perpendicular to the cricoid cartilage of the larynx, of which it forms the upper and anterior part. In men it is harder and more prominent than in women; it is sometimes called *Adam's apple*. The thyroid gland is situated upon the thyroid and cricoid cartilages of the trachea: it is of the class of ductless glands. When enlarged, it forms the bronchocele.

Thyrsula (Lat. thyrsus; Gr. θύρσος, *a sprout* or *stem*). The little cyme which is borne by the greater part of labiates in the axils of their leaves. It is sometimes called a *verticillaster*.

Thyrsus (Gr. θύρσος). A staff entwined with ivy, which formed part of the accoutrement of a Bacchanal, or performer in the orgies of Bacchus.

Thyrsus. In Botany, a form of inflorescence, consisting of a compact panicle, the lower branches of which are shorter than those of the middle; in other words, it is composed of a primary axis developing secondary axes from its sides, which in their turn develope tertiary axes, the upper and lower branches being shorter than those of the middle, as in the common Lilac.

Thysanurans (Gr. θυσάνουρος, *with a rough* or *fringed tail*). The name of an order of Ametabolian insects, comprehending those in which the abdomen is terminated by filaments, or by a forked tail adapted for leaping.

Tia. A Chinese name for *Sageretia theezans*.

Tiara (Lat.; Gr. τιάρας). An ornament with which the ancient Persians adorned their heads, in the form of a tower, ornamented with peacock's feathers. Xenophon says that it was sometimes encompassed with the diadem, and had frequently the figure of a half moon embroidered upon it.

This was the name also originally given to the mitre of the popes. It was nothing more than a round high cap, at first single instead of double, like that of other bishops. Nicholas I. added the first gold circle, as the sign of the civil power. The second was added by Boniface about 1300; the third by Urban V. about 1365. (Bowden, *Life of Gregory VII.* i. 60.)

Tiber Stone (Lat. Lapis Tibertinus). A name given to Travertine in consequence of the vast deposits of that substance formed by the water of the river Tiber.

Tibia (Lat.). In Anatomy, the largest of the two bones which form the second segment of the leg, or sacral extremity. In Entomology, it is the fourth joint of the leg, is very long, and usually triquetrous. It is said to have been so named from its resemblance, in the human skeleton, to the ancient pipe or flute.

Tic Douloureux (Fr.). A very painful affection of a nerve, coming on in sudden and excruciating attacks: it is perhaps most common in that branch of the fifth pair which comes out of the infra-orbitary foramen. The cause of tic douloureux is generally obscure;

occasionally it has been traced to disease of bone where spiculæ have been found pressing on the nerves. The treatment is uncertain, except where it assumes an intermittent form, and then large doses of tonics, especially quinine, arsenic, and carbonate of iron, have proved useful.

Tichorhine (Gr. τεῖχος, *a wall*, and ῥίς, ῥινός, *a nose*). The name of a fossil species of rhinoceros (*Rhinoceros tichorhinus*), so called from the middle vertical bony septum or wall which supports the nose.

Ticket of Leave. During the continuance of the system of transportation as an ordinary punishment, the practice was to release convicts, of good behaviour, before the regular expiration of their sentence, with a ticket of leave, i.e. a license to be at large, forfeitable on misconduct. When transportation was superseded by penal servitude, a similar system was introduced into convict prisons in England. [TRANSPORTATION.]

Tide Gauge. A mechanical contrivance for registering the state of the tide continuously at every instant of time. In the *Phil. Trans.* for 1838, there is a description of a very complete self-registering machine for this purpose, erected at Bristol by Mr. Bunt. The principal parts are an eight-day clock, which turns a vertical cylinder revolving once in twenty-four hours; a wheel, to which an alternate motion is communicated by a float rising and falling with the tide, and connected with the wheel by a wire passing over a pulley, and kept constantly strained by a counterpoise: and a small drum on the same axis with the wheel, which communicates one-eighteenth of the motion of the float to a bar carrying a pencil, which describes a curve on the cylinder, and marks the fluctuations and the time and height of high water. Various tide gauges, on similar principles, have been constructed by others, particularly by Captain Lloyd, Mr. Mitchell, Mr. Palmer, Mr. Bunt, Mr. Hewitson, and Mr. Newman. The chief improvements recently introduced into tide gauges are exhibited in that constructed by Hewitson. Great pains have been taken in every part of its construction to diminish friction as much as possible. The teeth of the wheels are carefully made, so that if the rise or fall of the tide should amount to the fraction of an inch only, a simultaneous movement of the machine follows to that amount. It is furnished with a brass cylinder turning on axes of bell-metal revolving in Y's. The traversing bar carrying the registering pencil moves on steel friction rollers, concealed in the capitals of the brass supporting pillars. The machine is connected with an astronomical clock, which needs winding only once in sixteen days, or in rather more than half a lunation, and thus produces, without any attention in this interval, a complete chart of tidal curves. (See the *Nautical Magazine* for October, 1832; *Phil. Trans.* for 1831 and 1838; and *Jury Report*, Class 10, *of the Great Exhibition of* 1851.)

Tide Mills. Mills which have the ebb and flow of the tide for their first movers. As the tide rises, the water is admitted into a reservoir through a sluice, over which the mill is built, turning the water-wheel in its passage through the sluice. At high tide the sluice gates are shut till the water has fallen sufficiently outside, when they are opened, so as to allow the water to flow out again from the reservoir, and turn the wheel as it escapes through the sluice.

In some tide mills the water-wheel turns one way as the tide rises, and the contrary as it falls; but in others an arrangement is adopted by which the wheel is made to turn always in the same direction. In some, the water-wheel rises and falls with the tide; and in others, the axis is fixed, so that it can neither rise nor fall. In the latter case, the power is applied at an obvious disadvantage. Instead of a water-wheel, a turbine may be employed to derive motion from the tide; or a species of blade may be used like the sails of a windmill, but with such a preponderance of surface on one side of the blade as to twist it into a right-hand screw when the water is rising and a left-hand screw when the water is falling, or vice versâ. By this arrangement the revolving axis will always be turned in the same direction, whether the tide is rising or falling.

Tides (A.-Sax. tid, Ger. zeit, Dutch tyd, *time*). The alternate rise and fall of the waters of the ocean. The moon is the principal agent in the production of the tides; but they are modified, both with respect to their height and the times at which they happen, by the action of the sun. The effect of the planets is inappreciable.

The attractive force of a body on a distant particle of matter varying inversely as the square of the distance, the particles of the earth on the side next the moon will be attracted with a greater, and those on the opposite side with a smaller force, than those which are situated intermediately. The gravitation towards the earth's centre of the particles nearest the moon will therefore be diminished, and consequently, if at liberty to move among themselves, they will rise above the general level. In like manner, the moon's attraction on the most distant particles being less than on the central ones, their relative gravitation towards the centre will also be diminished, and the waters will consequently be heaped up on the side of the earth which is turned away from the moon. Hence, if the earth were at rest, the ocean would take the form of an oblong spheroid, with its longer axis passing through the attracting body; and it may be shown from theory that the spheroid would be in equilibrium under the influence of the moon's attraction, if the longer semi-axis exceeded the shorter by about fifty-eight inches. But in consequence of the rapid rotation of the earth about its axis, the spheroid of equilibrium is never fully formed; for before the waters can take their level, the vertex of the spheroid has shifted its position on the earth's surface, in consequence of which an immensely broad and very flat

wave is formed, which follows the motions of the moon at some interval of time. In the open sea the time of high water is, in general, from two to three hours after the moon's transit over the meridian either above or below the horizon. The tidal wave, it is to be observed, is entirely different from a current: the particles of water merely rise and fall; but except when the wave passes over shallows, or approaches the shore, there is little or no progressive motion.

The waters of the ocean are affected in a similar manner by the action of the sun, under the influence of which they have a tendency to assume at every instant the form of an elongated spheroid; but although the attractive force of the sun is immensely greater than that of the moon, yet, by reason of his greater distance, the *difference* of the effect on particles situated on opposite sides of the earth (on which difference the phenomena depend) is very much less. The solar tides are therefore comparatively small with respect to the lunar tides, and, in fact, are never perceived as distinct phenomena, but become sensible only from the modifications which they produce in the heights and times of those which primarily depend on the moon. At the syzigies, when the sun and moon come to the meridian together, the tides are, *cœteris paribus*, the highest; at the quadratures, or when the sun and moon are 90° distant, the tides are least. The former are called *spring tides*, the latter *neap tides*. Although we are not in possession of data to enable us to compute the exact height either of the spring or neap tides, yet their relative heights in the open ocean probably correspond very nearly to the ellipticities of the spheroids of equilibrium that would be formed under the action of the two bodies exerted separately. Now, the ellipticity of the aqueous spheroid formed by the moon's action is about five feet, and the ellipticity of that formed by the sun's action about two feet; therefore, the spring and neap tides being the sum and difference of the separate effects, the average spring tide will be to the average neap in the ratio of about 7 to 3; i.e. of $5+2:5-2$. [GRAVITATION.]

By reason of the eccentricities of their orbits, the distances of the sun and moon from the earth are continually changing; and the theory of attraction proves that the efficacy of either body in disturbing the waters of the ocean is inversely proportional to the cube of its distance. Hence it is found that if the mean efficacy of the sun be represented by 20, the influence of the sun's action will vary between the extremes of 19 and 21, and that of the moon's between 43 and 59. The highest spring tide will therefore be to the lowest neap as $59+21$ to $43-19$; i.e. as 80 to 24, or as 10 to 3.

Another effect of the solar action is observed in the times at which high water takes place from day to day. In the spring and neap tides the time of high water is not altered by the sun's action, the solar and lunar tides being synchronous in the former case, and the time of actual low water being that of solar high water in the latter; but in the intermediate tides the time of actual high water is accelerated or retarded. In the first and third quarters of the moon, the solar wave is to the westward of the lunar one; and consequently the observed tide, which is the result of the combination of the two waves, will be to the westward of the place which it would occupy if the moon acted alone, and the time of high water will therefore be accelerated. In the second and fourth quarters, the general effect of the sun is to produce, for a like reason, a retardation in the time of high water. This result of the combined action of the two attracting bodies is what is usually termed the *priming and lagging* of the tides, and is most remarkable about the times of new and full moon.

It is to be observed, however, that the effect now described is modified to some extent by the inertia of the water. The greatest and least tides do not happen exactly at the times of new and full moon; but at least two, and commonly three tides after, even at places directly exposed to the general tide of the ocean. In consequence of the greater amount of impressed force, the acceleration of the lunar tide is greater than that of the solar; whence it may happen that when the lunar tide occurs two or three hours after the transit of the moon, the solar tide may be three or four hours after that of the sun, so as to be about an hour later at the times of conjunction and opposition. The highest spring tides will thus occur when the moon passes the meridian about an hour after the sun; while at the precise time of new and full moon the lunar tide will be retarded about a quarter of an hour by the solar tide. But the time of high water does not follow the moon's transit at the same interval at every period of the lunation. When the sun and moon are in conjunction, the interval is called the *mean interval*; at other periods of the lunation the lunitidal interval is sometimes greater and sometimes less than the mean, and the difference is called the *half-monthly* or *semi-menstrual inequality*.

The apparent time of high water at any port, in the afternoon of the day of new or full moon, is what is usually called the *establishment of the port*. Dr. Whewell calls this the *vulgar* establishment, and the mean of all the intervals of tide and transit for a half lunation he terms the *corrected* establishment. This corrected establishment is consequently the lunitidal interval corresponding to the day on which the moon passes the meridian exactly at noon or midnight.

The two tides immediately following one another, or the tides of the day and night, vary, both in height and time of high water, at any particular place with the distance of the sun and moon from the equator. As the vertex of the tide wave always tends to place itself vertically under the luminary which produces it, it is evident that, of two consecutive tides, that which happens when the moon is nearest the zenith or nadir will be greater than the other;

and consequently when the moon's declination is of the same denomination as the latitude of the place, the tide which corresponds to the upper transit will be greater than the opposite one, and vice versâ, the differences being greatest when the sun and moon are in opposition and in opposite tropics. This is called the *diurnal inequality*, because its cycle is one day; but it varies greatly at different places, and its laws, which appear to be governed by local circumstances, are very imperfectly known.

We have now described the principal phenomena that would take place if the earth were a sphere and covered entirely with a fluid of uniform depth. But the actual phenomena of the tides are infinitely more complicated. From the interruption of the land, and the irregular form and depth of the ocean, combined with many other disturbing circumstances—among which are the inertia of the waters, the friction on the bottom and sides, the narrowness and length of the channels, the action of the wind, currents, difference of atmospheric pressure, &c. &c.—great variation takes place in the mean times and height of high water at places differently situated; and the inequalities above noticed, as depending on the parallax of the moon, her position with respect to the sun, and the declination of the two bodies, are, in many cases, altogether obliterated by the effects of the disturbing influences, or can only be detected by the calculation and comparison of long series of observations.

By reason of these disturbing causes, it becomes a matter of great difficulty to trace the propagation of the tide wave, and the connection of the tides in different parts of the world. In the *Philosophical Transactions* for 1832, Sir John Lubbock published a map of the world, in which he inserted the times of high water at new and full moon at a great number of places on the globe, collected from various sources, as works on navigation, voyages, sailing directions, &c.; and in order that the march of the tide wave might be traced more readily, the times were expressed in Greenwich time as well as the time of the place. In the same *Transactions* for 1833, Dr. Whewell prosecuted this subject at greater length; and availing himself of à priori considerations, as well as of a mass of information collected in the Hydrographer's Office at the Admiralty, inserted in the map a series of *cotidal lines*, or lines along which high water takes place at the same instant of time. But these cotidal lines, as Sir J. Lubbock remarks, are entirely hypothetical; for we have few opportunities of determining the time of high water at a distance from the coast, though this is sometimes possible by means of a solitary island, as St. Helena. (Lubbock's *Elementary Treatise on the Tides*, 1839.)

According to Dr. Whewell's deductions, the general progress of the great tide wave may be thus described: It is only in the Southern Ocean, between the latitudes of 30 and 70 degrees, that a zone of water exists of sufficient extent to allow of the tide wave being fully formed. Suppose, then, a line of contemporary tides, or *cotidal line*, to be formed in the Indian Ocean, as the theory supposes, i.e. in the direction of the meridian, and at a certain distance to the eastward of the meridian in which the moon is. As this tide wave passes the Cape of Good Hope, it sends off a derivative undulation, which advances northward up the Atlantic Ocean, preserving always a certain proportion of its original magnitude and velocity. In travelling along this ocean the wave assumes a curved form, the convex part keeping near the middle of the ocean, and ahead of the branches, which, owing to the shallower water, lag behind on the American and African coasts; so that the cotidal lines have always a tendency to make very oblique angles with the shore, and, in fact, run nearly parallel to it for great distances. The main tide, Dr. Whewell conceives, after reaching the Orkneys, will move forward in the sea bounded by the shores of Norway and Siberia on the one side, and those of Greenland and America on the other, will pass the pole of the earth, and finally end its course on the shores in the neighbourhood of Behring's Straits. It may even propagate its influence through the straits, and modify the tides of the North Pacific. But a branch tide is sent off from this main tide into the German Ocean; and this, entering between the Orkneys and the coast of Norway, brings the tide to the east coast of England, and to the coasts of Holland, Denmark, and Germany. Continuing its course, part of it at least passes through the strait of Dover, and meets in the British Channel the tide from the Atlantic, which arrives on the coast of Europe twelve hours later; but in passing along the English coast another part of it is reflected from the projecting land of Norfolk upon the north coast of Germany, and again meets the tide wave on the shores of Denmark. Owing to this interference of different tide waves, the tides are almost entirely obliterated on the coast of Jutland, where their place is supplied by continual high water.

In the Pacific Ocean the tides are very small: but there are not sufficient observations to determine the forms and progress of the cotidal lines. Off Cape Horn, and round the whole shore of Tierra del Fuego, from the western extremity of the strait of Magalhaens to Staten Island, it is very remarkable that the tidal wave, instead of following the moon in its diurnal course, travels to the *eastward*. This, however, is a partial phenomenon; and a little farther to the north of the last-named places the tides set to the north and west. In the Mediterranean and Baltic seas the tides are inconsiderable, but exhibit irregularities for which it is difficult to account. The Indian Ocean appears to have high water on all sides at once, though not in the central parts at the same time.

Since the tides on our coasts are derived from the oscillations produced under the direct agency of the sun and moon in the Southern

Ocean, and require a certain interval of time for their transfer, it follows that, in general, the tide is not due to the moon's transit immediately preceding; but is regulated by the position which the sun and moon had when they determined the primary tide. The time which intervenes between the original formation of the tide and its appearance at any place is called the *age* of the tide, and sometimes, after Bernoulli, the *retard*. On the shores of Spain and North America the tide is a day and a half old; in the port of London, it appears to be two days and a half old when it arrives.

Velocity of the Tide Wave.—In the open ocean the crest of the tide travels with enormous velocity. If the whole surface were uniformly covered with water, the summit of the tide wave, being mainly governed by the moon, would everywhere follow the moon's transit at the same interval of time, and consequently travel round the earth in a little more than twenty-four hours. But the circumference of the earth at the equator being about 25,000 miles, the velocity of propagation would therefore be about 1,000 miles per hour. The actual velocity is perhaps nowhere equal to this, and is very different at different places. In latitude 60° south, where there is no interruption from land (excepting the narrow promontory of Patagonia), the tide wave will complete a revolution in a lunar day, and consequently travel at the rate of 670 miles an hour. On examining Dr. Whewell's map of cotidal lines, it will be seen that the great tide wave from the Southern Ocean travels from the Cape of Good Hope to the Azores in about twelve hours, and from the Azores to the southernmost point of Ireland in three hours more. In the Atlantic the hourly velocity in some cases appears to be 10° of latitude, or near 700 miles, which is almost equal to the velocity of sound through the air. From the south point of Ireland to the north point of Scotland the time is eight hours, and the velocity about 160 miles an hour along the shore. On the eastern coast of Britain, and in shallower water, the velocity is less. From Buchanness to Sunderland it is about 60 miles an hour; from Scarborough to Cromer, 35 miles; from the North Foreland to London, 30 miles; from London to Richmond, 13 miles an hour in that part of the river. (Whewell, *Phil. Trans.* 1833 and 1836.) It is scarcely necessary to remind the reader that the above velocities refer to the transmission of the undulation, and are entirely different from the velocity of the current to which the tide wave gives rise in shallow water.

Range of the Tide.—The difference of level between high and low water is affected by various causes, but chiefly by the configuration of the land, and is very different at different places. In deep inbends of the shore, open in the direction of the tide wave, and gradually contracting like a funnel, the convergence of the water causes a very great increase of the range. Hence the very high tides in the Bristol Channel, the bay of St. Malo, and especially the bay of Fundy, where the tide is said to rise sometimes to the height of 100 feet. Promontories, under certain circumstances, exert an opposite influence, and diminish the magnitude of the tide. The observed ranges are also very anomalous. At certain places on the south-east coast of Ireland the range is not more than 3 feet, while at a little distance on each side it becomes 12 or 13 feet; and it is remarkable that these low tides occur directly opposite to the Bristol Channel, where (at Chepstow) the difference between high and low water amounts to 60 feet. In the middle of the Pacific it amounts only to 2 or 3 feet. At the London Docks the average range is about 22 feet; at Liverpool 15·5 feet; at Portsmouth 12·5 feet; at Plymouth also 12·5 feet; at Bristol 33 feet.

Theory of the Tides.—The theory of the tides, considered as a consequence of solar and lunar attraction, was first sketched by Newton in the *Principia*. In the thirty-sixth and thirty-seventh propositions of the third book, he determines the forces of the sun and moon to elevate the waters of the ocean, on the supposition that the sea is a fluid of the same density as the earth, covering the whole terrestrial surface, and which takes at every instant the figure of equilibrium. He assumes, without demonstration, that this figure is an elongated spheroid. One spheroid he supposes to be formed under the action of the sun, another under the action of the moon; and by reason of the smallness of their eccentricities they may be conceived as superposed the one on the other. From these suppositions he deduced the general phenomena of the ebb and flow of the sea; and by comparing his theory with observations of the heights of the spring tides made at the mouth of the Avon, near Bristol, he determined the ratio of the attraction of the moon to that of the sun to be nearly 4·48 to 1; whence he deduced the mass of the earth to be to that of the moon as 39·788 to 1, the density of the sun to that of the earth as 1 to 4, and the density of the moon to that of the earth as 11 to 9. Newton's theory was defective in many points of view; but fifty years elapsed before it received any improvement. In 1738, the subject of the tides was proposed as a prize question by the French Academy of Sciences, which gave occasion to the celebrated treatises of Daniel Bernoulli, Maclaurin, and Euler. Maclaurin's Essay is remarkable, as containing a demonstration of the theorem assumed by Newton, that the elliptic spheroid affords an equilibrium under the action of the disturbing forces: those of Bernoulli and Euler, though they furnish no new principle of equal or similar importance in point of theory, enter more into details, and contain many useful illustrations. That of Bernoulli, indeed, contains a table which has served as the model for all those (not purely empirical) which have since been formed. The next important step in the theory of the tides was taken by Laplace, who first treated the subject as a general question

of hydrodynamics, and attempted to deduce the principal phenomena from the equations of the motions of fluids. But in order to simplify the equations, which are of a very complicated nature, he was forced to have recourse to the hypothesis of a fluid covering entirely a spheroid of a regular surface, and consequently the results were far from representing the actual observations of the tides at any port. The late Dr. Thomas Young (*Ency. Brit.* art. 'Tides') extended Laplace's method to the more general case of an ocean covering a part only of the earth's surface, and more or less irregular in its form; and attempted also to include in his calculation the effects of hydraulic friction on the times and magnitudes of the tides. It is, however, quite impossible to embrace in any calculation the whole of the accessory circumstances which influence the times and magnitudes of the tides, the greater part of which are, in fact, entirely unknown; and therefore Laplace maintains that we can do no more than analyse the general phenomena which should result from the joint action of the sun and moon, and deduce from observations the data indispensable for completing the theory of the tides for each particular port.

A great number of observations of the tides at the port of Brest, during the last century, were discussed by Laplace in the *Mécanique Céleste*; but in order to determine the motion of the tide wave, and separate the general laws of the phenomena from local irregularities, it is necessary to have regular series of observations made at different parts of the ocean. In 1829, Sir John Lubbock undertook the discussion of the tide observations which are made at the London Docks, with the view of obtaining correct tables for predicting the time and height of the tides for the *British Almanac.* The results, which were published in the *Philosophical Transactions* for 1831, are deduced from a series of upwards of 13,000 observations, during a period of nineteen years, and are of great importance, both as affording materials for the construction of tide tables, and as pointing out the defects of the equilibrium theory, with which they were accurately compared. In some of the subsequent volumes of the *Transactions* the author has continued his investigations, and has also published, separately, an account of Bernoulli's *Traité sur le Flux et Reflux*, and an elementary treatise, which appeared in 1839. In the *Phil. Trans.* for 1833, Dr. Whewell gave an *Essay towards a first Approximation to a Map of Cotidal Lines*, which has been followed by a series of interesting papers in the subsequent volumes to the year 1850. Dr. Whewell's researches were chiefly directed to the determination of the following points: First, the motion of the tide wave at different parts of the ocean; secondly, the comparison of the observed laws at different places with theory; and, lastly, the laws of the diurnal inequality. In 1834, the British Association caused an extensive series of observations to be made on the coasts of Britain and Ireland at 537 stations of the coast-guard. These were repeated at the same places in June 1835; and, at the request of our government, simultaneous observations were made by the other maritime powers of Europe and the United States. The number of stations in America was twenty-eight, extending from the mouth of the Mississippi to Nova Scotia; and the number on the continent of Europe 101, between the straits of Gibraltar and the North Cape of Norway. The results of these observations, reduced under Dr. Whewell's superintendence, were published in the *Phil. Trans.* for 1836; and they are of great importance, not only as affording a far more precise determination of the progress of the tide wave and the forms of the cotidal line on the coasts of Europe and North America than had previously been attained, but as furnishing more correct data for the construction of the tide tables. (*Phil. Trans.* for 1842, 1843, and 1845, memoirs by Mr. Airy on the Laws of the Tides at Ipswich and Southampton, in the River Thames, and on the Coasts of Ireland.)

Influence of Atmospheric Pressure and Winds.—Besides the numerous causes of irregularity depending on local circumstances, the tides are also affected by the state of the atmosphere. At Brest, the height of high water varies inversely as the height of the barometer, and rises more than eight inches for a fall of about half an inch of the barometer. At Liverpool, a fall of one-tenth of an inch in the barometer corresponds to a rise in the river Mersey of about an inch; and at the London Docks, a fall of one-tenth of an inch corresponds to a rise in the Thames of about seven-tenths of an inch. With a low barometer, the tides may therefore be expected to be high, and vice versâ. The tide is also liable to be disturbed by winds. Sir J. Lubbock states that, in the violent hurricane of January 8, 1839, 'there was no tide at Gainsborough, which is twenty-five miles up the Trent—a circumstance unknown before. At Saltmarsh, only five miles up the Ouse, from the Humber, the tide went on ebbing, and never flowed till the river was dry in some places; while at Ostend, towards which the wind was blowing, contrary effects were observed. During strong north-westerly gales the tide marks high water earlier in the Thames than otherwise, and does not give so much water, whilst the ebb tide runs out late, and marks lower; but upon the gales abating, and the weather moderating, the tides put in, and rise much higher; whilst they also run longer before high water is marked, and with more velocity of current; nor do they run out so long or so low.' (*Elementary Treatise on the Tides*; Airy's 'Treatise on Tides and Waves,' *Ency. Metrop.*)

Tie. In Architecture, a piece of timber or metal placed in any direction, for the purpose of binding two bodies together which have a tendency to separate or diverge. [Roof.]

Tie. In Music, a character ⌣ used to connect notes which are divided by a bar, and

which are nevertheless intended to be joined together and sounded without any break.

Tiemannite. A name for the mineral Onofrite, after the discoverer Tiemann.

Tier. The battery of guns on one side of a ship's deck. *Cable-tier* is the place below where the cable is coiled: also the hollow space in the midst of the coil.

Tierce (Fr. tiers, Lat. tertius). In Heraldry, a term used for the field when divided into three parts.

Tiern. [LAIRD.]

Tiers État (Fr.). The third branch, or commonalty, in the French Estates. The origin and meaning of the word are illustrated by M. Gautier. (*Mém. de l'Acad. des Inscr.* vol. xxxvii.) Down to the time of the great French revolution, the French were divided into three distinct classes, the nobles, the clergy, and the commonalty, forming in their united capacity the states-general of the kingdom: and their deliberations were separately conducted by individual vote in different chambers, in which the three classes respectively assembled. They then met in common to deliberate together, and vote collectively. Now, as the number of the deputies was nearly equal in each order, the result of the votes taken collectively was always necessarily favourable to the privileged orders. Hence it was loudly demanded that the number of the third estate should be doubled, and the definite resolutions decided by individual instead of collective votes. It was owing to the refusal of the nobles and the clergy to comply with this demand, that the crisis of the French revolution was accelerated. [ASSEMBLY.]

Tiger (Lat. tigris, from a Persian word signifying *an arrow*). A species of the genus *Felis*, as large as the lion, but with a rounder head and longer body; of a bright reddish fawn colour above, a pure white below, irregularly crossed with black stripes. It is clothed with short hairs, and has no mane. The tiger is the most formidable and cruel of all quadrupeds, and the scourge of the less inhabited parts of India. It is limited to the Asiatic continent. [FELIS.]

Tiger Wood. The heartwood of *Machærium Schomburgkii*, a valuable cabinet wood obtained from British Guiana.

Tikor. An Indian name for the tubers of *Curcuma leucorrhiza*, as well as for a kind of arrowroot prepared from the tubers.

Til or **Teel.** The Indian name for *Sesamum orientale* and *S. indicum*, the seeds of which are commonly known as Til-seed. The black-seeded variety is Kala-til; the white-seeded, Suffed-til. Ram-til is the seed of *Guizotia oleifera*.

Til Wood. The timber of *Oreodaphne fœtens*, which has a foul smell.

Tile-ore. An impure oxide of copper, of a brick-red or reddish-brown colour. It is an earthy variety of Red Copper, mixed with variable proportions of hydrous oxide of iron or Limonite, and is found at Huel Edward, and in several of the Cornish mines near Redruth.

Tiles, Encaustic. A species of tiles with ornamental figures of different coloured clays indented on their surfaces. Such tiles were much used by the architects of the middle ages. The art of manufacturing them was revived about the year 1833 by Mr. Wright of the Staffordshire potteries, and soon after that time the manufacture was perfected by Minton. A good buff colour and a warm red are produced by firing certain clays in their natural state. Black is produced by staining with manganese, blue by staining with cobalt. The clays, after having been well washed and purified, are passed through lawn sieves in the liquid or *slip* state, as it is technically termed; and when brought to the right consistence, the clay intended to form the body of the tile is pressed into an iron mould, the bottom of which is formed of a plaster of Paris pattern bearing the design to be impressed on the tile. The pattern being removed, the indentations are filled with the coloured clays according to the intended design, and the surface is then shaved off so as to remove all superfluities and ruggedness, leaving the pattern intact. The tile is then dried for two or three weeks, and is finally fired by exposing it to an intense heat for sixty hours.

Tilestone. The name given in Geology to a well-marked series of hard finely laminated micaceous and quartzose sandstones and shales forming the top of the Silurian series in Caermarthenshire and the adjacent counties of Wales. The beds thus named occupy the highest part of a bold escarpment, 1,500 to 1,600 feet above the sea. They are in some places rich in fossils agreeing with those of the underlying Silurian deposits, and in many localities are quarried for excellent flags used in roofing. The corresponding beds in Cumberland and the Lake district possess excellent slates, but the typical tilestone has only flags, though these exhibit fair cleavage and are very finely laminated.

The tilestone was long regarded as at the base of the Old Red Sandstone series. Its position among the Silurians is now fully recognised.

Besides the tilestone of the Silurian period, there are many instances of fissile stones capable of being used for roofing obtained from rocks of various geological periods.

Tilia (Lat. *the lime-tree*). A genus of large-growing deciduous trees representing the order *Tiliaceæ*, and entirely confined to the temperate countries of the northern hemisphere. They have alternate heart-shaped leaves, and small yellowish highly fragrant flowers, borne in axillary cymes, which have a curious long leaf-like bract attached to their stalks.

The Common Lime or Linden, *T. europæa*, attains a height of from sixty to a hundred and twenty feet. It is found throughout the whole of Europe, except the extreme north, one small-leaved variety being indigenous to

Britain. The large-leaved variety commonly planted is, however, a native of the south of Europe. Various parts of this tree are applied to useful purposes. The white, soft, but close-grained wood is used by carvers and turners, and by musical instrument makers for sounding-boards. The tough inner bark is called *bass* or *bast*, and is the material of which the Russian mats used by gardeners and upholsterers are made; the Russian peasants also make shoes, ropes, nets, and other articles with it. The sap yields sugar, and the flowers an abundance of honey, of which bees are fond.

Tiliaceæ (Tilia, *the linden* or *lime tree*). A natural order of hypogynous Exogens, very nearly allied to the Malvaceous order, from which they differ in the stamens being distinct. They consist of trees or shrubs, rarely herbs, with alternate stipulate leaves, and usually cymose flowers, and are chiefly characterised by a valvate calyx, indefinite hypogynous stamens, and a free ovary divided into several cells, with the placentas in the axis. The calyx connects the order with *Malvaceæ* and *Sterculiaceæ*, from which it is distinguished chiefly by the stamens. The species are numerous, especially within the tropics. In useful qualities they resemble the *Malvaceæ*, their bark being tough, their sap mucilaginous, and their timber light. Russia mats are made from the tough inner bark of the common Lime-tree [Tilia], and *Corchorus olitorius* is employed in India as a potherb. A few have gay flowers, but the majority are plants of little interest to gardeners.

Tilkerodite. This name is applied to those varieties of Clausthalite in which part of the lead is replaced by cobalt. The name has reference to the locality (Tilkerode in the Harz) where the mineral is found.

Till. A widely spread clayey mass belonging to the newer part of the drift period, and composed generally of more angular blocks than the fresh-water marls and gravels of the newest part of the same period in the south of England. Parts of the till are known as the Boulder Clay. In one form or other, rocks of this age extend over all parts of northern Europe. They do not generally contain many fossils, though now and then both shells and bones are found in them. [Drift.]

The name *till* was originally given in Scotland to a particular deposit, for the most part unstratified, containing blocks of stone of all dimensions, mixed with mud, sand, and clay. Among the blocks, some are rounded, but most of them are angular, and their average dimensions increase as we advance northwards. The thickness of this deposit is sometimes a hundred feet, and it seldom contains organic remains of any kind. There can be little difficulty in referring this deposit to the glacial period. It must have been formed when Scotland was under water, and when icebergs drifted down from the polar seas, to be stranded on shoals, there leaving the accumulation of mud and stone derived from higher latitudes.

Occasional passages can be found from the *till* to stratified clay, gravel, and sand, occasioned perhaps by the sorting action of the water on the confused mass originally deposited, and by the action of marine currents intervening at certain seasons.

Tillage of Land. The relations of population to the cultivation of the soil will be determined partly by the occupation of the soil, and in part by the rate of production from the soil. The soil of a given country, again, may be partly unoccupied, sometimes from the fact that the needs of the population may not have imposed the obligation of cultivating inferior soils, or all soils of equal natural fertility but of unequal convenience or proximity to human habitations, as in newly settled countries; sometimes, from the fact that agricultural science is so imperfectly developed that much which at one time might be available has not hitherto been turned to any economical use, as in the middle ages. Again, the land of a given country may be generally occupied and tilled, but the rate of production may be very scanty, either because the soil is naturally defective in some of those elements which are necessary for abundant produce (as in mountainous countries), or if some of those appliances are wanting, out of which the rate of production may be largely increased (as was the case before the discovery of artificial grasses and saccharine roots). All these various states might be more fully illustrated and compared with that condition in which (the highest skill and security, and the most intelligent labour, being superadded to natural fertility) the maximum of population is maintained on the minimum area of tillage. This state of things is never, of course, attained, and, as all science is progressive, is not in fact attainable, though perhaps under some circumstances the limit of productiveness is nearly reached; and it should be added, that however extended may be the sphere of practical science, its economical application can never be commensurate, unless all political and social freedom—by which we must understand the extension to each man of all rights which do not trench on the rights of other men—is fully and permanently attained. The agricultural science, such as it was, of Cato, Virgil, and Columella did not save Italy from dissolution, and the old world from barbarism, because the Roman empire suffered under a military despotism, and added to the political evils of the empire the debasing and retrograde influences of slavery.

It is clear, when any given country imports no food from abroad, or none of any importance or regularity, that the amount of population will be limited to the numbers which can be maintained on the produce. If agriculture be greatly developed, if the rate of production be high, and mechanical arts are largely substituted for manual labour, the number of persons not engaged in tilling the soil will be great; and, conversely, when mechanical science is ill understood or not applied, when the rate of production is scanty, and the arts of agri-

culture are undeveloped, the number of persons who can be spared from the cultivation of the soil is very small, manufactures are imperfect, and foreign trade is scanty. The former of these conditions characterises in a general way the present social state of England; the latter represents its state in the middle ages. It should be remembered, also, that the arts of agriculture imply the production and improvement of stock, as well as the growth of corn, and that the food of cattle is only second in importance, as far as regards the economy of husbandry, to the supply of bread for man.

It is probable that, five hundred years ago, the amount of arable land in England was not much less than it is at present. It is true that large areas have been enclosed and cultivated within the last 150 years. The first enclosure Act (Ropley in Hampshire) was passed in the reign of Queen Anne. But much land which was once under the plough has been built on, much has been turned into park and pleasure ground, not a little has been lost by the encroachments of the sea or by subsidence of land; while the accretions due to the upheaval of land or the retrocession of the sea do not seem to be equal in quantity, still less equal in value. But it is clear that the amount producible annually from the soil of England and Wales five centuries ago could not have been sufficient for the maintenance of more than two millions of people.

In the first place, the rate of production in grain was very low. Eight bushels to the acre of wheat, i.e. four times the seed sown, was a good crop in a plentiful year, and was, it seems, very rarely exceeded. At present, thirty bushels may be taken as a fair crop on average wheat land. Crops of barley and oats, though generally larger in quantity than in the case of wheat, were, compared with the produce of modern times, proportionately scanty.

Our forefathers knew absolutely nothing of those saccharine roots which play so important a part in the economy of a farm. Turnips, carrots, and parsnips, and of course potatoes, were unknown. The first three of these were imported into England (it would seem from Holland) at or about the beginning of the seventeenth century. Potatoes, as is well known, were brought from North America towards the end of the fifteenth century. It will be plain, however, that in the total absence of those roots, comparatively few cattle and sheep, and those generally in poor condition, could have been maintained. Indeed, the practice was to kill at about the middle of November all cattle and sheep which could not well be kept through the winter, and salt them as winter provisions. The remaining stock was half-starved, and could never have been in prime order. Hence fat was four times the price of meat.

Again, the English farmer in the middle ages had no knowledge of artificial grasses. At the present time it is very hard to say which of our grasses are native, but it is generally believed that few of the best kinds are indigenous. The clovers, of course, are of foreign origin. Hence upland hay was very poor, and natural water meadow, though it supplied the most valuable and abundant hay, was deficient in saccharine or fat-producing elements; and further, the want of root and artificial grass crops necessitated fallows, for in the absence of stock, land could not be sufficiently manured for the purposes of a continuous rotation.

With little more than a fourth as much wheat as is now sown, with one-fourth less wheat-bearing land (if we admit that an equal amount of land was devoted to the plough) owing to the system of fallows, with no root crops and artificial grasses, with cattle small and weak, sheep light and half-starved, it does not seem likely that the population could have been more than a tenth of the number now maintained on English produce. It might very well be less, and instead of being two millions, it may have been no more than one and a half.

The cultivation of the soil was attended with great expenses. The horses, it seems, were very small, the oxen light. The rude ploughs merely scratched the ground, while iron and all iron implements were excessively dear. The price of iron five hundred years ago was not less than 8*l.* a ton in money of the time, i.e. was worth 24*l.* in silver, and if we estimate the general rise in the value of silver, as deduced from the prices of corn and other necessaries at those times, would in modern money at modern values cost 72*l.* the ton. So great a charge in the raw material from which agricultural implements were made must have been a serious hindrance to the progress of agriculture. The rent of good arable land was seldom more than 6*d.* an acre, i.e. when interpreted by the same standard, 4*s.* 6*d.* in modern value, and after the great plague of 1348 fell considerably below this amount.

For further information as to the state of agriculture in England during the period referred to, the reader is referred to *The History of Agriculture and Prices in England*, by Professor Rogers; for the amount of population at the conclusion of the seventeenth century (when agriculture had made great progress), to the works of Davenant and Gregory King; for the eighteenth century, to those of Arthur Young; and for the later facts, to Porter's *Progress of the Nation*, and the classification of occupations in the Census reports.

Tillandsia (after Prof. Tillands, of Abo). A genus of *Bromeliaceæ*, consisting of tropical and extra-tropical American herbaceous plants, growing frequently on trees, and covered with scurfy scales. Some of these plants serve as natural reservoirs for water in their native forests. The water flows down the channelled leaves, which are dilated at the base, so as to form a bottle-like cavity capable of containing a pint or more, and travellers tap these vegetable pitchers for the sake of the fluid which they contain. *T. utriculata*, a native of Jamaica, and many others have this property of storing

water. Dr. Gardner, in his *Travels in Brazil*, relates that a certain species of *Utricularia* grows only in the water collected in the bottom of the leaves of a large *Tillandsia*. The aquatic plant throws out runners, which direct themselves to the nearest *Tillandsia*, and there form new plants. In this way, several *Tillandsias* may sometimes be seen connected together.

T. usneoides, a native of the West Indies and the Southern States of America, hangs down from the trees like a tuft of long grey hair, much like certain lichens (*Usnea*) in European pine-forests. The trees in some parts of Central America have a strange gaunt appearance, from the profusion of this *Tillandsia* growing from their branches. The plant is collected, and steeped in water in order to remove the outer cellular portion, and the fibrous portion is then employed in place of horsehair to stuff cushions, mattresses, &c.

Tiller. In Naval language, the lever placed in the head of the rudder to turn it, and in a ship worked by the wheel.

Tilmus (Gr. τιλμός, from τίλλω, *I pluck*). Picking of the bed-clothes, or floccitation; a symptom of the fatal termination of some disorders.

Tilt (A.-Sax. teld). A small awning over the stern-sheets of an open boat.

Timber (A.-Sax.). In Commerce, wood used for building purposes. In a country like ours, which is very densely peopled, the supply of wood for building and naval purposes falls far short of the demand, and it is necessary that the deficiency should be met by foreign importation. This necessity is met by the abundant forests of Sweden and Norway, Russia and Canada.

Timber was originally liable to small and uniform duties. But during the great continental war and the unfortunate administration of Mr. Vansittart, whose financial policy was a continual series of extravagant errors, the Canadian lumberers and some shipowners induced the government to establish discriminating duties on Russian and other Baltic produce. The duties on Canadian timber were reduced, and in 1809 all but repealed, while that on Baltic timber was doubled. This action might have been justified on the miserable plea of retaliation. But after Napoleon's disastrous retreat from Moscow, and the restoration of English navigation to the Baltic, a further addition of 25 per cent. was laid on European timber, and ultimately, in 1819, the tax was fixed at 3*l.* 5*s.* the load of 50 cubic feet.

A tax on timber is in the highest degree inexpedient, because it is, in the first place, a tax on raw material, and such taxes multiply themselves in manufactured goods, and involve inevitably a greater loss to the public than they bring gain to the exchequer; and, in the next place, it is a tax on a commodity which, being in some degree produced at home, raises the price of home-grown timber by the full amount of the tax, and therefore charges the public with the enhanced price over all the timber *used*, while the government obtains the tax only over all the timber imported. But a discriminating tax on timber is even more indefensible, particularly since the kinds which come lightly taxed (those, namely, from Canada) are vastly inferior to those which were overtaxed (those, namely, from the Baltic). The effect of the duty was to compel the public to pay a high price for an inferior article.

The differential duties on timber, having been considerably modified in 1851, were equalised in 1860, and altogether repealed by the budget of 1866. Since 1858 the consumption of foreign timber has increased enormously.

It may be added, that when timber is sawn into pieces not above seven inches broad, the article is called *battens*; when above that breadth, *deals*. The term *wood* is used generally also to include ornamental timber and even dye stuffs.

Imports of Timber for the Seven Years ending with 1865.

Timber and Wood	1859	1860	1861	1862	1863	1864	1865
Not sawn or split:—	loads	loads	loads	loads	loads	loads	loads
Foreign countries	626,293	690,956	705,102	818,071	777,599	786,029	964,5[illegible]
British possessions	515,666	584,153	629,419	504,931	699,229	694,349	666,271
Total	1,141,959	1,275,109	1,334,521	1,323,002	1,476,828	1,480,378	1,631,1[illegible]
Sawn or split:—							
Foreign countries	739,875	768,424	876,298	962,884	1,121,566	1,205,045	1,348,52[illegible]
British possessions	732,792	684,382	850,319	600,142	781,342	781,036	787,961
Total	1,472,667	1,452,806	1,726,617	1,563,026	1,902,908	1,986,081	2,136,491
Staves	115,616	76,869	48,518	51,899	58,587	62,786	67,58[illegible]
	tons	tons	tons	tons	tons	tons	tons
Mahogany	35,701	44,710	53,108	53,798	47,998	41,008	51,376

Timber. This term in a Legal sense includes in all cases oak, ash, and elm; but other trees (as, for instance, beech or birch) may be timber by the custom of particular counties or districts. (Craig *On Trees*.)

Timbers. In Shipbuilding, the ribs on which the vessel is framed. Each comprises (reckoning from the keel) the cross-piece, or half-floor, the several futtocks, the top-timbers, and, if necessary, the lengthening pieces. At the top, the timbers are all capped by the rough-tree-rail; below they are mortised on to the keel.

Timbre (Fr.). A word borrowed from the French, and used in Acoustics to signify the quality of a musical sound, termed by the Germans klangfarbe, *sound-tint*. When precisely the same note is sounded on two different musical instruments, say a pianoforte and an organ, although the *pitch* of the note, i.e. the number of vibrations per second, is the same in both, yet the two sounds are quite distinct. This distinction is due to a difference in the *timbre* of the two notes. The Germans express this by saying the sound has a different colour or tint in the two cases. This peculiar quality in musical sounds is caused by the mingling of a series of secondary tones with the primary one. When, for example, the string of a pianoforte is struck, the string, whilst vibrating as a whole, is at the same time divided, and again subdivided, into aliquot vibrating segments, which, as it were, ride on the back of the principal vibration. These vibrating subdivisions give rise to a series of higher notes, of gradually lessening intensity, called the *harmonics* of the primary note. The character and number of these harmonics coexisting with the principle note, is the cause of the timbre or quality of sound peculiar to different musical instruments. For the greater part of our knowledge of this subject we are indebted to the admirable researches of Prof. Helmholtz, a clear exposition of which, with much additional information, will be found in Prof. Tyndall's work *On Sound*.

Timbrel (Span. tamboril, Fr. tambour). In Music, a kind of drum or tabor, used from a very remote age.

Time (Fr. temps, Lat. tempus, literally *a portion*, from the root of the Gr. *τέμνω, I cut*). A limited portion of duration, measured by certain conventional or natural periods, and often marked by particular phenomena, as the apparent revolution of the celestial bodies, more especially of the sun, or the rotation of the earth on its axis.

Absolute Time is time considered in itself without reference to that portion of duration to which it belongs, however noted or marked.

Relative Time is time considered with reference to the termini of some specific interval of duration.

Apparent Time is time deduced from observations of the sun, and is the same as that which is shown by a properly adjusted sundial.

Mean Time is the time shown by a well-regulated clock; and would be the same as that shown by the sun, if the sun were always in the equator and his apparent diurnal motion in the heavens were uniform.

Sidereal Time is the portion of a sidereal day which has elapsed since the transit of the first point of Aries. It represents at any moment the right ascension of whatever object is then upon the meridian.

Astronomical Time of Day is the time past *mean noon* of that day, and is reckoned on to twenty-four hours in mean time.

Civil Time is mean time adapted to the purposes of civil life. The day commences at the midnight preceding the noon of the day, and is divided into parts of twelve hours each, the first twelve marked A.M. or *ante meridiem*, and the second P.M. or *post meridiem*.

TIME. In Metaphysics. [SPACE, NUMBER, AND TIME.]

TIME. In Music, this word has several significations.

1. It refers to the length of the different kinds of notes, a description of which is given in the article MUSIC.

2. It refers also to the number and arrangement of the notes in each bar or measure, which is always indicated by certain figures or signs at the commencement of the piece. Thus, a piece is said to be in *common* or *triple time*, as the primary division of the measure is into two or three parts, and so on. [MUSIC.]

3. It refers also to the *uniformity* of velocity throughout the piece; a performer who plays equal notes with unequal lengths being said not to *keep time*.

4. The word also refers to the *absolute* velocity with which music is played: thus, we say, a piece is in *quick*, or in *slow*, or in *moderate time*. The time in which a piece should be played, is indicated by Italian words placed at the commencement of the piece, some of which, however, are only figuratively expressive of time, their real meanings referring more to style; the following are the words most commonly in use for this purpose, beginning with the slowest:—

Grave: *grave, heavy*.
Lento: *slow*.
Largo: *broad*.
Larghetto: diminutive of *largo*.
Adagio: *leisurely*.
Andante: *going*.
Andantino: diminutive of *andante*.
Allegretto: diminutive of *allegro*.
Allegro: *joyfully*.
Con moto: *with movement*.
Vivace: *lively*.
Presto: *quick*.
Prestissimo: *very quick*.

The words più (*more*), meno (*less*), or poco (*little*), added to these, affect their significations accordingly.

The time in which music should be taken has of late years been generally indicated by the METRONOME.

Timocracy (Gr. τιμοκρατία). A term made use of by some Greek writers, especially Aristotle, to signify a peculiar form of constitution; but there are two different senses in which it is thus used, corresponding to the different meanings of the word τιμή, *a price* or *honour*, from which it is derived. According to the first, it represents a state in which the qualification for office is a certain amount of property; in the latter it is a kind of mean between aristocracy and oligarchy, when the ruling class, who are still the best and noblest

citizens, struggle for pre-eminence amongst themselves.

Tin (Ger. zinn, Fr. étain, Lat. stannum). This metal, the Jupiter (♃) of the alchemists, is represented by the symbol Sn (stannum) and by the equivalent 59. It has been known from remote ages, and is said to have been obtained at a very early period from Spain and Britain by the Phœnicians. It occurs most abundantly in Cornwall, the mines of which afford about 3,000 tons annually: it is also found in Germany, Bohemia, and Hungary; in Chili and Mexico; in the peninsula of Malacca; and in India, in the island of Banca. The *native peroxide* is the principal *ore of tin*: the metal is obtained by heating it to redness with charcoal or culm, and a little lime; the first product is impure, and is returned into the furnace, and carefully heated so as to fuse the tin, which runs off into an iron kettle, while the principal impurities remain unmelted; in the kettle the tin is kept in fusion, stirred, and agitated by plunging billets of green wood into it. The impurities thus collected upon the surface are removed by a skimmer; and the metal is then cast into blocks of about 3 cwt. each. The common ores, known under the name of *mine tin*, furnish a less pure metal than that obtained from *stream tin*. The purest tin is known under the name of *grain tin*, a term formerly applied exclusively to the metal obtained from the stream ore: *block tin* is less pure, and is the produce of the common ore. The peculiar columnar fracture which pure tin exhibits when broken, is given by heating the ingot till it becomes brittle, and then letting it fall from a height upon a hard pavement.

Tin has a silvery-white colour with a slight tint of yellow, and when so viewed as to exclude the white light reflected from its surface, it is decidedly yellow: it is softer than gold, but harder than lead: it is malleable, though imperfectly ductile. What is termed *tinfoil* is the metal beaten out into thin leaves, but it is seldom pure and the common commercial article generally contains from 30 to 40 per cent. of lead. The foil frequently used for packing articles of food, confectionery, tea, &c. is lead thinly plated with tin, and is more easily oxidised than the separate metals, so that it may in some cases give rise to lead-poisoning. Traces of arsenic are also not uncommon in it. The sp. gr. of tin fluctuates from 7·28 to 7·6, the lightest being the purest metal. When bent, it occasions a peculiar crackling noise; and when rapidly bent backwards and forwards several times successively, it becomes hot, a circumstance due to the friction between the crystals. When rubbed, it exhales a peculiar odour. It melts at 442°, and slightly contracts on consolidation. By exposure to heat and air it is gradually converted into protoxide (SnO); but if the heat be continued till metallic tin no longer remains, the protoxide passes into peroxide (SnO_2). Placed upon ignited charcoal under a current of oxygen gas, it enters into rapid combustion, forming the peroxide; and if an intensely heated globule of the metal be thrown upon a sheet of dark-coloured paper, it subdivides into small particles, which burn very brilliantly and leave lines of white oxide. It volatilises at a very high temperature. When a polished surface of tin is heated, it becomes yellow and iridescent, in consequence of superficial oxidation. A preparation, under the name of *powdered tin*, is sometimes made by shaking the melted metal in a wooden box rubbed with chalk on the inside. The substance called *tin putty*, used for polishing plate, is made by levigating the crusts of oxide that form on melted tin.

Protoxide of Tin; *Stannous Oxide* (SnO).—This product is obtained by precipitating a solution of protochloride of tin by ammonia; it falls in the state of *hydrate*. It is obtained *anhydrous*, by heating it in a glass tube, passing a current of dry carbonic acid over it till the water is carried off, and suffering it to cool out of the contact of air. The specific gravity of this oxide is 6·6. It forms a dark-grey or black powder, which, on the contact of a red-hot wire, burns like tinder into peroxide. In the hydrated state it dissolves readily in sulphuric, hydrochloric, and dilute nitric acids, as well as in caustic potash and soda, but not in ammonia, nor in the alkaline carbonates.

When a solution of protochloride of tin is mixed with moist hydrated sesquioxide of iron and boiled, an interchange of elements takes place, by which protochloride of iron and sesquioxide of tin are formed: $2SnCl + Fe_2O_3 = Sn_2O_3 + 2FeCe$. This oxide in ammonia is distinguished from protoxide by its solubility, and from peroxide by its giving a purple precipitate with chloride of gold. It is soluble in concentrated hydrochloric acid. It may be represented as a stannate of the protoxide, by the formula SnO, SnO_2.

Peroxide of Tin; *Binoxide of Tin* (SnO_2).—This is the common ore of tin: in its crystalline form it is insoluble in acids, but when heated with potash or soda it forms a soluble compound. There are two remarkable varieties of the hydrate of this oxide, which have been distinguished as *stannic* and *metastannic acid*. *Stannic acid* (SnO_2, HO) is obtained by precipitating a solution of bichloride of tin by ammonia, and washing and carefully drying the precipitate: it is soluble in acids, and in solutions of potash and soda, but not in ammonia. When heated to about 300°, it passes into metastannic acid. *Stannate of Potash* is formed when peroxide of tin is heated with potash. *Stannate of soda* (NaO, SnO_2, 4 HO) may be similarly prepared and crystallised: it is largely used as a mordant by dyers and calico-printers.

Metastannic acid is the result of the action of nitric acid upon tin: in its most concentrated form nitric acid does not immediately act upon tin, but on the addition of a few drops of water violent effervescence ensues, much heat is evolved, together with nitric oxide and nitrous acid vapour; some nitrate of ammonia is also

formed; and the metastannic acid remains in the form of a white insoluble powder: it may be purified by washing, and dried at a dull red heat. When dried in the air it consists of Sn_5O_{10}, 10HO: dried at 212° it loses 5HO, and at a red heat becomes anhydrous, and acquires a pale buff colour. Hydrated metastannic acid is insoluble in nitric acid: it dissolves in sulphuric acid, forming a compound soluble in water, but decomposed by boiling. It dissolves in solutions of potash and soda, and their carbonates, but not in ammonia, The *metastannates* are not crystallisable.

Native Peroxide of Tin is generally grey, brown, or black, and sometimes transparent or translucent; its specific gravity is 7: its primitive crystal is an obtuse octahedron, of which there are very many modifications. In some of the valleys of Cornwall it is found in nodules mixed with pebbles, and is called *stream tin*. A modification of stream tin, in small banded fragments or globular masses, is called *wood tin*.

Protochloride of Tin (Sn Cl) is obtained by subjecting a mixture of 1 part of tin filings and 2 of corrosive sublimate to distillation. When tin is dissolved in hydrochloric acid, the solution evaporated, and the dry residue carefully heated to incipient redness in a small tube retort, so as to exclude air, the protochloride of tin remains nearly pure. It is in the form of a grey solid, fusible and volatile at a high heat (*butter of tin*). When its solution in a small quantity of water is evaporated, it yields prismatic crystals, which include 3 atoms of water. The protochloride of tin, or *salt of tin* of commerce, is made by putting 1 part of granulated tin into a basin upon a sand-bath, and pouring upon it 1 part of hydrochloric acid; after some hours 3 parts more of the acid are added, and the mixture stirred and digested till a saturated solution is obtained. During the process, fetid hydrogen gas is given off, and the greater part of the tin is dissolved; when the clear liquor is poured off, it is set aside to crystallise; the mother liquors are again evaporated as long as they afford crystals, and the residue is afterwards employed for conversion into bichloride.

With solution of gold, this protochloride produces a purple precipitate used in painting porcelain, under the name of PURPLE OF CASSIUS. With infusion of cochineal, it produces a purple precipitate; and it is much used to fix and alter colours in dyeing and calico-printing.

Perchloride of Tin ($SnCl_2$).—If tin is heated in excess of chlorine, or if a mixture of one part of tin filings and four of corrosive sublimate is distilled, the perchloride will pass over. It is a transparent colourless fluid, formerly called LIBAVIUS'S FUMING LIQUOR: it exhales copious fumes when exposed to moist air; and with one-third its weight of water it forms a crystallised hydrate = ($SnCl_2$5HO). A solution of perchloride of tin, much used by dyers, is made by dissolving tin in a mixture of two measures of hydrochloric acid, one of nitric acid, and one of water.

Bisulphide of Tin (SnS_2) is obtained as follows: Take 12 oz. of tin and amalgamate it with 6 oz. of mercury; reduce it to powder, and mix it with 7 oz. of sublimed sulphur and 6 oz. of sal ammoniac, and put the whole into a glass matrass placed on a sand-bath. Apply a gentle heat till the white fumes abate, then raise the heat to redness, and keep it so for a due time. On cooling and breaking the matrass, the bisulphide of tin is found at the bottom. The use of the mercury is to facilitate the fusion of the tin and its combination with the sulphur, while the sal ammoniac prevents such increase of temperature as would reduce the tin to the state of protosulphide.

The extraordinary golden lustre of the bisulphide of tin, and its flaky texture, rendered it an object of great interest to the alchemists: it was termed *aurum musivum*, and *mosaic gold*. When well made, it is in soft golden flakes, friable and adhering to the fingers. It is used for ornamental work, under the name of *bronze-powder*, especially by the manufacturers of paper-hangings: it is chiefly imported from Holland and Germany.

Tin plate is a most useful alloy of tin and iron, in which iron plate is superficially alloyed with tin, and to the surface of which a quantity of tin further adheres, without being in combination. It is made by dipping cleansed iron plates into a bath of melted tin. An objection to such combinations is, that in consequence of the electrical relations of the metals, the iron, if anywhere exposed, has an increased tendency to oxidation: for although the surface of the tin itself is sufficiently durable, no sooner is any portion so abraded as to denude the iron, than a spot of rust appears and rapidly extends: hence the superiority of iron plate covered by zinc instead of tin, zinc being electro-positive, whereas tin is electro-negative in regard to iron, under the influence of common oxidising agents.

Moiré métallique is tin plate which has been superficially acted on by an acid, so as to display, by reflected light, the crystalline texture of the tin. [MOIRÉ MÉTALLIQUE.]

The *tinning of pins* is effected by boiling them for a few minutes in a solution of one part of a bitartrate of potash, two of alum, and two of common salt, in ten or twelve of water, to which some tin filings or fragments of finely granulated tin are added; they soon become coated with a film of tin, and are then taken out, cleaned, and dried. The pins are made of brass wire, and require to be perfectly clean before they are put into the tinning liquor. Tin medals, or casts in tin, are *bronzed* by being first well cleaned, wiped, and washed over with a solution of one part of protosulphate of iron, and one of sulphate of copper, in twenty of water—this gives a grey tint to the surface; they are then brushed over with a solution of four parts of verdigris in eleven of distilled vinegar, left for an hour to dry, and polished

with a soft brush and colcothar. [BLOCK TIN.]

Tin Plate. [TIN.]

Tin Pyrites. Native sulphide of tin, copper, and iron. It occurs, when pure, of a steel-grey colour, which, however, often inclines to brass-yellow owing to an admixture of Copper Pyrites, at Carn Brea and other Cornish mines, and also in the granite-veins of St. Michael's Mount.

Tin Stone. The common name for native oxide of tin or Cassiterite.

Tinca (Lat. *a tench*). A subgenus of Cyprinoid fishes, characterised by having short anal and dorsal fins; very short barbules or tentacles about the mouth; no bony serrated ray at the commencement of either the dorsal or anal fins; small scales. Like the rest of the Linnæan *Cyprini*, the *Tinci*, or tenches, have no teeth except in the pharynx; whence the name of *leather-mouthed fishes* applied to this family of *Pisces Abdominales*.

Tincal. The Oriental name for Borax.

Tincture (Lat. tinctura, from tingo, Gr. τέγγω, *to wet* or *moisten*). A Pharmaceutical preparation, generally consisting of active remedies dissolved in rectified or in proof spirit. Tinctures are generally made by digesting bruised or pulverised vegetable substances in spirit, either at common temperatures or aided by heat. Various ingenious inventions have been in use of late years, by which these tinctures are prepared and filtered without access of air. The term *tincture* is also applied to alcoholic solutions of resins, of which tincture of myrrh is an instance. Tinctures, from the quantity of alcohol which they contain, are necessarily exhibited in small doses: the most important are those which contain highly active ingredients, such as opium, &c.

Tinctures. In Heraldry, tinctures are of three kinds: metals, colours, and furs. The former are or, argent; the second gules, azure, sable, vert, purpure, sanguine, and tenny. The chief furs are ermine and vair; but there are several varieties of both, distinguished by different names. Each metal and colour, in blazonry (except the two last and least honourable, sanguine and tenny), is represented by a distinct precious stone and heavenly body; and when the arms of sovereign princes or high dignities are described by old heralds, the tinctures are frequently denoted by the names of these jewels or celestial bodies. [ARGENT; OR; &c.]

Tinder Ore. An impure arsenical sulphide of antimony and lead found in soft flexible flakes, resembling reddish tinder, at Andreasberg and Clausthal in the Harz.

Tinea (Lat. *a small worm* or *moth*). The scald head. [RINGWORM.]

Tinkalzite. A hydrous borate of lime and soda from Peru, which is used in the arts as a substitute for borax.

Tinkar's Root. The root of *Triosteum perfoliatum*.

Tinospora. A genus of *Menispermaceæ*, consisting of climbing Indian shrubs, with thickened jointed leafstalks and long axillary or terminal clusters of flowers. It has been remarked in reference to the extreme vitality of these plants, that when the main trunk is cut across or broken, a rootlet, speedily sent down from above, continues to grow till it reaches the ground and restores the connection. A bitter principle, *columbine*, pervades the species, many of which have tonic and emetic properties. An extract called *Guluncha* is considered to be a specific for the bites of poisonous insects, and for ulcers, and is prepared from *T. cordifolia* and *T. crispa*. It is administered as a diuretic and tonic in cases of fever, and is also employed in snake bites. The young shoots of *T. cordifolia* are used as emetics.

Tipstaff. A species of constable in attendance on the courts of chancery and common law, appointed formerly by the warden of the Fleet Prison and the marshal of the Queen's Prison, but now by the Lord Chancellor, the Lord Chief Justices, and the Lord Chief Baron respectively. (Stat. 5 & 6 Vict. c. 22.)

Tirailleurs (Fr.). Literally, men who shoot carelessly or at random, and hence denoting those individual soldiers, who, though firing at an object, were themselves scattered from the main body of troops, and did not fire together. The word is now used in the French army in the sense of *sharpshooters* or *skirmishers*.

Tirolite. [TYROLITE.]

Tironian Notes. The short-hand of Roman antiquity. According to the received story, they were introduced into Rome by Tiro, the freedman and favourite of Cicero: he is supposed to have imported the art from Greece. MSS., written entirely in what are called the Tironian notes, are not unfrequently of the date of the seventh century and downwards; and they are still common in marginal notes. (Kopp, *Tachygraphia Veterum Exposita*; Carpentier, *Alphabetum Tironianum*, 1747.) Tassin, in the third volume of his *Nouveau Traité de Diplomatique*, attempted, with more or less success, to decipher the Roman abbreviations. Some have thought that valuable lost classics may be recovered through this key; but as yet these hopes have been nugatory. (*Ed. Rev.* vol. xlviii. p. 357 &c.)

Tisane (Fr.; Gr. πτισάνη, *barley water*). A drink prepared in France from the flowers of *Malva sylvestris*.

Tisri. The first Hebrew month of the civil year, and the seventh of the ecclesiastical year. It corresponds to part of September and October.

Tissue (Fr. tissu). In animals, the substance of which systems of organs are composed, as e.g. bone, or *osseous tissue*, in the osseous system; flesh, or *muscular tissue*, in the muscular system; *neurine*, or nervous tissue, in the nervous system; *dentine*, or tooth-bone, in the dental system. The branch of Anatomy which treats of the tissues is termed HISTOLOGY.

Tissue. In plants, the thin membranous organisation of which every part is composed, microscopical in size, and often appearing to the naked eye homogeneous, although it consists of a great variety of forms closely compacted. Vegetable anatomists regard its primitive form as spheroidal, and maintain that the tubes and spiral vessels are mere extensions of that form. Tissue appears in all plants to be of the same nature originally, but it soon becomes altered by the deposition of various secretions upon its sides.

Titan (Gr.). In Greek Mythology, this word generally occurs in the plural number, and is applied to the children of Uranus and Ge. Among them was Cronos, the father of Zeus, and through him of the Olympian gods. (Hesiod. *Theog.* 133 &c.) The children of the Titans, as Atlas, Prometheus, &c., also retained the name. The Titans themselves, at the close of their war with Zeus, were thrust down into Tartarus. [THEOGONY.]

Titanite. Native oxide of titanium.

Titanium. A metal discovered by Gregor in a mineral from Cornwall called MENACCANITE. Its characters were first ascertained by Klaproth, who gave it the above name. In the year 1822, Dr. Wollaston ascertained the presence of a large proportion of titanium in the minute copper-coloured crystals occasionally found in the slag of the iron smelting furnaces at Merthyr and elsewhere. They are of a copper colour, almost infusible, of a specific gravity of 5·8, and so hard as to scratch not only glass but crystal. They resist the action of air and acids, but are oxidised by the action of nitre at a red heat. It has since been ascertained that these crystals contain about 18 per cent. of nitrogen and 4 of carbon, and are probably a mixture of nitride with cyanide of titanium. The equivalent assigned to titanium is 24, and the peroxide, or titanic acid, is TiO_2. Titanium appears susceptible of two degrees of oxidation. The protoxide is blue or purple, and appears to constitute the mineral called *anatase.* The peroxide exists nearly pure in *titanite,* or *rutilite,* and is combined with the oxides of iron and manganese in *menaccanite.* The properties of pure titanium are but little known.

Tithe (A.-Sax. teotha; the Scotch form is teinds). In Ecclesiastical Law, the tenth part of the produce of the land, which, in this and other Christian countries, was anciently set apart for the endowment of the church. The Levitical ordinance has frequently been appealed to under the Christian dispensation, as establishing the divine right of the clergy to the receipt of tithes for ever; but this ground of claim has been generally abandoned in modern times. The duty of paying tithes was first enjoined, apparently, in certain ecclesiastical canons, in the year 750; and the first civil decree upon the subject is discovered in the laws of Offa, king of Mercia, in 794. In France, a similar law was enforced by Charlemagne in 778, and from that time the payment has been continued without interruption to modern times.

Of tithes there are, or rather were, three kinds: 1. *Predial,* of the vegetable productions of the land, as corn, hay, &c.; 2. *Mixed,* as of wool, pigs, &c., which, though natural products, are nurtured and preserved by the care of man; 3. *Personal,* as of manual occupations, trades, fisheries, and the like. Another division of tithes is into *great* and *small,* or *parsonage* and *vicarage tithes*: of these, the former are chiefly corn, hay, and wood; the latter are predial tithes of other kinds, together with mixed and personal tithes. The great tithes belong to the RECTOR; whereas only the small tithes are due to the VICAR. By the original law, all the land of the country was titheable, excepting the property of the crown, and of the church itself. But when, at the Reformation, the monasteries were dissolved, and their estates granted for the most part to laymen, these lands would have become titheable again, but for a particular statute (31 Hen. VIII. c. 13) which was enacted for the advantage of the new possessors. It was also allowable, up to the 13 Eliz., to effect compositions between the clergy and owners of the land, by which the parish was discharged of these payments for ever, in consideration of lands made over to the parson in exchange. This practice was restrained by a statute passed in 13 Eliz. which limited all such compositions to a period of three lives or twenty-one years. From these causes, however, we find a great deal of land in the hands of lay proprietors not subject to this charge. The monasteries are said to have held one-third of the benefices of the kingdom, the tithes belonging to which they received, appointing members of their own body, as their vicars or curates, to discharge the ordinary functions of parochial ministers. To these they either gave fixed stipends, or allotted the small tithes, taking, as their own share, the great or rectorial tithes. This is called *appropriation* of tithes; but when these benefices fell into the hands of laymen, the same practice was continued, and is distinguished by the title of *impropriation.*

Lands and their occupiers might be discharged from the payment of tithes, either in part or totally, by a composition, or by custom or prescription.

Such is the general view of the law of tithe immediately previous to the great changes introduced by the Tithe Commutation Act, 6 & 7 Wm. IV. c. 71; the object of which was to convert a tax, imposed on the gross produce of the soil, and varying annually in amount as well as money value along with it, into a rent charge, perpetual as to the amount, but varying according to the money value.

By this Act the money value of the tithes in each parish was to be calculated according to the average of the seven years ending at Christmas, 1835, minus the expenses of collecting, &c.; but without deduction on account of parochial or county rates, &c. The com-

missioners appointed for that purpose under the Act were then to award that sum (subject to some unimportant allowances), as the amount of the rent charge to be paid in respect of the tithes. This rent charge was to be apportioned among the lands of the parish, having regard to their average titheable produce and productive quality. The rent charge, being thus valued in money, was to be taken as the price of such a quantity of wheat, barley, and oats as it would have purchased (each grain in equal quantities), according to the average price at the period of the confirmation of the apportionment. That quantity of grain was therefore to remain for ever as the annual charge upon the parish. In order to regulate the money amount of the tithes, the money payment each year was to be equal to the price of that quantity at the average of the seven years immediately preceding, to be ascertained by an advertisement of the comptroller of corn returns, published in the month of January every year. The rent charge was to be paid by the occupiers of the land on which it was apportioned.

According to the returns under the property tax (1810), it appeared that about 8,000,000 acres in England and Wales were tithe-free, and 21,000,000 titheable. Mr. M'Culloch's *Statistics of the British Empire* contains the following analysis of appropriations, &c. of tithes:—

Belonging to the crown	38
Archbishops and bishops	385
Ecclesiastical corporations aggregate	702
Dignitaries and other ecclesiastical corporations sole	438
Universities, colleges, and hospitals	281
Private owners	2,552
Municipal corporations (since sold)	43
Vicarages partly endowed	121
Ditto wholly endowed	132

TITHE. In Finance and Political Economy, a tax levied on produce, and strictly a *tenth* of the amount produced. The term is also used loosely for any proportionate quantity taken by way of tax and for such taxes as are intended for other purposes than those to which tithes are ordinarily devoted, viz. the maintenance of ecclesiastics and ecclesiastical buildings.

The economical effect of a tax on produce is not mischievous when agriculture is rude and land is unimproved by artificial means. The tax is a simple property tax, which takes in equal proportion from rich and poor soils. But when land is made capable of cultivation by a large outlay of fixed capital, as, for instance, by drainage, or by artificial irrigation, or by the superposition of vegetable soil upon a barren surface, a tithe is exceedingly unjust, since it taxes unequal capitals at equal rates. A tithe has therefore been always viewed by economists as a great hindrance to improvement, because it forms a tax on improvement, and where it has not been confiscated en masse, it has been commuted to a fixed rent charge. Such has been the change effected in this country.

Titienses. [EQUITES.]

Title. In Bibliography and Printing, the first page of a book, giving in a few lines—the fewer the better—a notion of the subject of the work. This page is usually left till the body of the work is completed, as circumstances may alter the author's intentions as to title, preface, date, dedication, &c. The sheet containing these parts of a book is marked for the binder by *signature* A, and, if more than a sheet, by a, b, &c. It is not, as Professor de Morgan observes, an easy or every-day matter to choose a good title for a book; and the difficulty is constantly increased by the increase in the number of books on any particular subject. A title-page is a matter of literary importance greater than most people imagine: priority of conception gave birth to the felicitous titles of the *Spectator*, the *Tatler*, and other early works; but later titles of essays of a similar kind, such as the *Idler*, the *World*, &c., are unfortunate. Jewish and Oriental authors were partial to allegorical titles, some of them remarkably puerile; but the Greeks and Romans showed considerable taste in the names of their books. Some of the English titles of the seventeenth century were in the worst taste, such as *The Sixpenny-worth of Divine Spirit*, Baxter's *Shove*, *A Pair of Spectacles for Sir Humphrey Lind*, *A Fan to drive away Flies*, &c.

Title to Property. It is obvious that the bare possession of property does not always indicate that the holder is entitled absolutely to dispose of it. The actual occupier of a house or land is in most cases only a tenant for years, and it very frequently happens that the landlord or the person assuming to act as owner of an estate has, in fact, only a life interest in it, or has mortgaged or otherwise encumbered it. It is therefore necessary, upon every sale or mortgage of lands, to investigate the title of the person who is about to convey, for the purpose of ascertaining as far as possible that he has a right to do so, and that the purchaser or mortgagee will, after he has parted with his money, be safe against disturbance by other claimants. The period for which a title is investigated is for the last sixty years, and every vendor of freehold property is bound to furnish the intended purchaser with an abstract of all the deeds, wills, and other instruments which have been executed with respect to the lands in question during that period, and to furnish proper evidence of deaths and other material facts. The precise term of sixty years is usually supposed to have been adopted, or at least continued, with a view to the ordinary duration of human life. For as long as the law allows land to be settled on a man for life, and after his death on his son, or some other remainder-man, so long must it be necessary to carry the title back to such a point as will afford a reasonable presumption that the first person mentioned

as having conveyed the property, was not a tenant for life merely, but a tenant in fee simple.

The case is different with respect to most kinds of personal property. Money and negotiable securities (such as bills of exchange, &c.) pass freely from hand to hand; and, in the case of theft or misappropriation, the true owner has no right to require restitution of his property from any innocent holder of it not privy to the offence. Ordinary merchandise or goods, if stolen, may in some cases be reclaimed by the rightful owner; but this risk is not sufficient to make it worth while, as a general rule, for a purchaser to ask any questions with respect to his vendor's title. As regards stock in the public funds and shares in public companies, a purchaser of them will be safe if he obtains a proper transfer from the person in whose name they are standing, unless he has notice that they belong to some one else. Stock and shares, and many other kinds of personal property, such as mortgage investments and the like, are frequently made the subject of settlements; but property of this nature (unlike real property) can be settled only through the medium of trustees, and when settled is usually treated as a temporary investment representing so much money, and is not, like a landed estate, intended to remain in specie in the same family. It is therefore the practice, in order to facilitate changes of investment, to give to the trustees of settled personal property the fullest powers of disposing of it without rendering it necessary for purchasers from them to investigate the title of the person beneficially interested. It happens, however, not unfrequently, that reversionary or other interests in personal property are sold or mortgaged by the beneficial owners before the time has arrived for an absolute division or apportionment of the settled funds, and under these circumstances an enquiry into the title becomes as necessary as in the case of real estate.

The necessity of a detailed enquiry into title is undoubtedly a great source of expense and delay in dealing with land; and with a view to remedy these evils an Act has been passed 'to facilitate the proof of title to, and the conveyance of, real estates.' (Stat. 25 & 26 Vict. c. 67.) Under this Act, an office for land registry has been established, in which landowners may submit their titles to official investigation, and have them registered in case they are approved of as good and marketable. Provision is made for the registration of land either with an indefeasible title, or with a title subject to specific incumbrances. And it is enacted that the persons described in the 'record of title to land on the registry,' as entitled to any land, are, subject to the specified qualifications or incumbrances, if any, and for the purposes of sales, mortgages, and contracts for valuable consideration, to be deemed absolutely and indefeasibly entitled to such estates, rights, powers, and interests, as shall be expressed on the record; the practical effect of which provision is that investigation and reinvestigation of the title on the occasions of *subsequent* sales, mortgages, &c., will become in a great measure unnecessary. The Act, however, is permissive only, and has not at present been made use of to any great extent. Between October 15, 1862 (when the office of land registry was opened), and June 10, 1865, there were 291 applications made for registration of titles, 43 of which (relating to property of an aggregate value of 622,050*l.*) had at the latter date been completed or were ready for completion, 35 had failed or been withdrawn, and the rest were still pending in the office. By a later parliamentary return, made up to March 10, 1866, it appears that up to that date the total number of applications under the Act had been 359, 114 of which (relating to property of a total value of 1,443,547*l.*) had been completed or were ready, and 53 had failed or been withdrawn.

Titmouse. [PARUS.]

Titular (Lat. titulus, *a title*). Chiefly in Ecclesiastical usage, a person invested with the title to a benefice: generally used for one who has the title only, without possession or enjoyment. The term, however, has been in some cases applied to the possessors of the property of suppressed bishoprics, &c.

Tiza. The name given to the native borate of lime (Hayesine) in Southern Peru.

Tjettek. A Javanese name for the virulent poison prepared from *Strychnos Tieuté*.

Tmesis (Gr. from τέμνω, *I cut*). In Grammar, a figure by which a compound word is separated into two parts by the intervention of one or more words, as in the following line of Terence, 'Quæ meo cunque animo lubitum est facere,' for 'quæcunque meo animo.' This figure is a license in the Latin language, frequent in Terence and Lucretius, rare in later writers; in the Greek it is more common; but of all Western languages, the German lends itself most readily to the division of compound words. In English the figure is unused.

Toad (A.-Sax. tade). The kind of tailless Batrachian, common in Britain, which exemplifies the family *Bufonina*, having half-webbed toes, the glandular swelling called *parotoid* between the eye and ear, and the sacral diapophyses expanded. The genus *Bufo* has the femur rather short; no teeth; tongue elliptical, entire, with the free margin turned back; skin more or less warty. Toads exist in almost every part of the globe except Australia. The parotoids exude a fetid and rather acrid milky secretion, which is the sole foundation for the vulgar error of the poison of the toad. The animal is useful to man, and in no way noxious.

Toad's-eye Tin. A pale hair-brown variety of Wood Tin found at several mines near Tregurthy Moor in Cornwall.

Toadstone (Ger. todtstein, *dead-stone*). The name given by miners to certain bands,

generally basaltic, which alternate with bands of limestone of the carboniferous series. It has been found by experience, that when metalliferous (lead-bearing) veins exist in these strata, the ore is rarely present where the vein traverses the basalts, and thus these rocks are said to be *dead*, as not being productive. This name is applied chiefly in Derbyshire. [CARBONIFEROUS LIMESTONE; TRAP-ROCK.]

Toadstools. The common name for various species of *Agaricus* and *Boletus*, common fungi, which, according to the notion of older herbalists, derived their origin from toads, as puffballs (*Lycoperdon*) derived theirs from wolves, or deerballs (*Elaphomyces*) from deer.

Tobacco. The dried leaves of the *Nicotiana Tabacum*, a plant indigenous to America, but which succeeds well, and is extensively cultivated, in most parts of the Old World. The recent leaves possess little odour or taste; but when dried, the odour becomes strong and peculiar, and their taste bitter and acrid. When distilled, they yield a volatile principle called *nicotine*, on which their virtue depends, and which is a virulent poison. There is also obtained a concrete volatile oil which appears to possess active properties.

The leaves are used in various ways, being chewed, smoked, or ground and manufactured into snuff. It is in the last-mentioned form that tobacco was, till of late years, principally used in Great Britain. Much discussion has arisen of late years respecting the practice of smoking tobacco, it having been argued, on the one hand, that the custom is invariably injurious, and that the nervous system suffers materially even in those who indulge in a moderate degree. On the other hand, smokers urge the fact that the practice can scarcely be injurious, inasmuch as it cannot be shown that smoking interferes with longevity, and that many men of high intellect have been inveterate smokers and have lived to a good old age. The subject has been treated by the late Sir Benjamin Brodie and by Mr. Solly. The former does not consider smoking in moderation more injurious than the moderate use of wine, though he highly disapproves of the excessive use of tobacco. Mr. Solly takes a strong view, and believes all use of tobacco injurious.

The term *tobacco* is probably derived from Tobaco, a province of Yucatan, where it was first found by the Spaniards. To Sir Francis Drake and Sir Walter Raleigh has been ascribed the honour of having introduced it into England, nearly three centuries ago.

Tobago Canes. A name under which the slender trunks of *Bactris minor* are sometimes imported into Europe, to be made into walking-sticks.

Tocsin. An old French word, of which the derivation seems not to be ascertained: Gregory of Tours uses the word *seing* for the sound of a bell (*Ency. Méthodique*), signifying an alarum-bell (Ger. sturmglocke). The use of the tocsin, during the troubles of the Revolution, to assemble the multitude, has rendered the word almost proverbial.

Tocusso. An Abyssinian corn-plant or millet, bearing the scientific name of *Eleusine Tocusso*.

Tod. A weight used in weighing wool. It contains twenty-eight pounds avoirdupois.

Toddy. The juice which flows from the spathes of *Borassus flabelliformis*, *Raphia vinifera*, *Mauritia vinifera*, *Arenga saccharifera*, the cocoa-nut, date, and other palms, when they are cut or wounded. This juice forms Palm wine. It is a delicious beverage when fresh, and is employed in India by bakers instead of yeast in the preparation of bread; it is also extensively distilled into a spirituous liquor, generally drunk by the natives, among whom it is known by the name of *bowra*.

Tods' Tails. A Scotch name for the common Highland Clubmosses.

Toffs. The fragrant flowers of the North African *Rhaponticum acaule*.

Toft. An Anglo-Saxon word, denoting strictly the tuft of trees sheltering a homestead, and sometimes surrounding it. In old deeds it is commonly joined to *croft*, another Anglo-Saxon word meaning an enclosed field.

Toga (Lat.). The gown or mantle peculiar to the Roman people; whence it was sometimes designated as the *gens togata*, or toga-clad nation. The toga was a loose flowing woollen garment covering the whole body round, close below, but open at the top down to the girdle. The end was drawn up and thrown over the left shoulder, leaving the right arm free, as it had no sleeves. The ordinary colour of the toga was white; but this was changed for a dark colour in mourning. The chief dignitaries of the state were distinguished by a purple band affixed to the edge of the toga, which was then called *prætexta*. An embroidered toga was worn by generals when they triumphed. (Rich, *Dictionary of Roman and Greek Antiquities*.)

Among women, the toga was only worn by the disreputable; the dress of the matron was the STOLA.

Toggel. A double cone of wood, firmly fixed in a loop at the end of a rope. By passing the toggel through another small loop in another rope, a strong junction is easily formed, which can be cancelled in a moment. Toggels are very useful in bending flags for signals.

Toise (Fr.). A French measure of length, containing six French feet, or 1·949040 mètres. The French toise is equivalent to 6·3945925 English feet. In Old English the equivalent of toise, i.e. *tey* or *teys*, is the same as the fathom.

Tokay. A wine made at Tokay in Hungary; it is luscious, and yet has an agreeable quickness of flavour. It is usually more or less turbid.

Token (Ger. zeichen; the root is found in the Gr. δείκνυμι, and the Lat. indicare, *to show*). Up to the Restoration, the government issued no copper money for purposes of

small change. There had been indeed no great necessity for such a currency in early times. The greater part of agricultural wages was paid in kind, there were no shops, and very little foreign produce was distributed by means of retail trade. Such articles of this character as were procurable, were obtained at those great fairs which played so important a part in mediæval and even in later economy, but which are now almost extinct. Besides, the denomination of the silver currency, before the reforms of Elizabeth, was low, pence being coined which were divisible by means of a cross on the reverse into four parts or farthings. As, however, intercourse with the Eastern world was made more familiar after the discovery of the Cape passage, and the English merchants contended with the Portuguese, Spaniards, and Dutch for a share in this lucrative trade, the supply of foreign commodities became more copious, and their use more diffused. Retail traders became more numerous, and supplied articles in smaller parcels, and the want of a small change currency was felt. To meet this want, and possibly to obtain some profit on the transaction, private individuals issued, there being no law to the contrary, copper pieces, called *tokens*, which the person whose name they bore pledged himself to redeem in silver, on demand. There was scarcely a village of any magnitude in which such a local currency did not circulate, and a complete collection of such tokens, if indeed it could be made, would contain many thousand specimens. The custom continued even up to the restoration of the currency in 1819, the Bank of England having for a short time even issued a currency of silver tokens.

This copper circulation was of a nature similar to those issues of notes in very small denominations which have characterised many foreign currencies. The value of the metal contained in the token was of course far below its nominal rate, and the circulation, if it could be effected in any quantity, was a source of considerable profit to the issuing parties, since during the time that the tokens were accepted and circulated, the proprietors of the local currency got the interest on the difference between the value of the tokens and the silver which they represented. Nor, except on the ground that it is an advantage to the state to retain the issue of the copper currency in its own hands, is there any reason why such a currency of tokens might not be permitted, as well as an issue of local notes. It is, however, a considerable advantage to the government to retain the monopoly of coining silver and copper, and it has therefore forbidden the issue of these tokens. It is well known that the silver and copper coins of this country are considerably overrated, and that therefore they are, to all intents, a currency of government tokens.

TOKEN. In Printing, ten quires eighteen sheets of *perfect* paper, or 258 sheets. It is reckoned an hour's work for a hand press, of ordinary work. In Moxon's time the token was ten quires.

Toleration (Lat. toleratio, from tolero, *I endure*). This word is used in a general sense to express impunity and safety in the state for all dissenters from the established church, who do not maintain any doctrines inconsistent with the peace and welfare of the state. Hence toleration implies a right of enjoying the benefit of the laws and of all social privileges, without any regard to difference of religion. The first toleration Act in England was passed in 1689; but it was not till 1829, when the Catholic Emancipation Bill was passed, that dissenters could be said to be on an equality with churchmen in every respect. For the connection between the idea of toleration and the secularisation of politics, see Lecky's *History of Rationalism in Europe*, ch. v.

Toll (A.-Sax.; Ger. zoll). The name usually given to the duties imposed on travellers and goods passing along public roads, bridges, &c. It is also used to indicate the payment to the corporation of a town, or to the lord or owner of a market or fair, upon sale of things tollable. Toll is sometimes taken by a man for every beast driven across his ground, and is then called *toll-traverse*; also by a town for beasts going through it, or over a bridge or ferry maintained at its cost, and is then called *toll-thorough*. The right to take an ancient toll rests upon prescription or a grant from the crown; tolls of modern introduction are established by Acts of Parliament, of which the Turnpike Acts are familiar instances. [TAILLE.]

Tolmen or **Dolmen.** In Antiquities. Borlase, in his *History of Cornwall*, gives this name to large stones with passages apparently hollowed through them, which are commonly believed to be Druidical remains. Other antiquaries describe under this name stone tables or altars resting on stone supports. There are so-called Tolmens in the Channel Islands, Brittany, Poitou, and in the central parts of France. See also *Archæologia*, vol. ii. and vol. viii. p. 210, where there is a description and representation of a celebrated one at Primham Rocks, in Yorkshire.

Tolsey. An ancient name for a place where tolls were assessed or collected, and at which, consequently, other mercantile business was often carried on. Thus a local court at Bristol was known as the Tolsey court. The word *Tolbooth* has, no doubt, a similar origin.

Tolu Balsam. The concrete balsam of *Myrospermum toluiferum*, a tree growing in the warmest parts of South America. This substance is pale brown; brittle in cold, but tenacious in hot weather; fragrant when heated, and entirely soluble in alcohol. It contains *cinnamic acid*.

Toluidine. An organic base obtained by the action of sulphide of ammonium upon nitro-toluol. It is a white crystalline substance, fusing at 104° Fahr. (40° C.), and boiling at 386·4 Fahr. (198° C.). Its formula is $C_{14}H_9N$.

Toluol. An oily hydrocarbon obtained by distillation from Tolu Balsam; it also exists in coal tar. Its composition is $C_{14}\ H_8$. It boils at 237·2 Fahr. (114° C.).

Tomato (Malay tamatta). The Love-apple, *Lycopersicum esculentum*, a Solanaceous plant, whose fruits are much esteemed in cookery. The *Solanum anthropophagorum*, which the Feejeans eat at their feasts of human flesh, is hence called the *Cannibal's Tomato*.

Tomb (Gr. τύμβος, Lat. tumulus). This word, which signifies strictly a place where a dead body is burnt, is commonly used to denote both the grave or sepulchre in which the body of a deceased person is interred, and a monument erected in his memory. In many countries it was customary to burn the bodies of the dead, and to collect the ashes into an Urn, which was deposited in a tomb. The tombs of the Jews were generally hollow places hewn out of a rock. The Greeks constructed their tombs outside the walls of their cities, with the exception of those raised to distinguished personages. The same distinction was observed by the Romans; their sepulchres were in the country near the high roads, and none but emperors, vestals, and great personages had the privilege of burial within the walls. In Etruria, many ancient tombs have been discovered containing beautiful vases, for full particulars respecting which the reader may consult Dennis's *Cities and Cemeteries of Etruria*. See, for the tombs of the Egyptians, Sir G. Wilkinson's *Manners of the Ancient Egyptians*, vol. iii. p. 183.

Tombac. An alloy of copper and zinc, or a species of brass with excess of zinc. When arsenic is added, it forms *white tombac*.

Tombazite. A variety of Gersdorffite, containing nickel, arsenic, and a little sulphur, with traces of cobalt and iron. It is found in cubical crystals of a bronze-yellow or pinchbeck-brown colour, near Lobenstein in Thuringia.

Tomentose (Lat. tomentum). In Botany, this term is applied to surfaces covered with dense scarcely rigid short hairs, so as to be sensibly woolly to the touch.

Tomentum (Lat.). In Botany, the down which produces the tomentose character on the surface of plants.

Tomoisite. An amorphous compact silicate of manganese from the Harz.

Tompion (Fr. tampon). In Artillery, a conical plug or stopper, placed in the muzzle of a gun to keep out the wet.

Ton (A.-Sax. tunna). A denomination of weight equal to 20 cwt. or 2,240 lbs. avoirdupois. The *long ton*, often used in wholesale dealings, is equal to 21 cwt. or 2,352 lbs. avoirdupois. *Ton* is also the name of an English measure of capacity containing 252 gallons; but when used in the latter sense, the word is usually written *tun*.

Ton. On Shipboard, forty cubic feet.

Tonality. In Music, this rather vague word is used generally to denote that peculiarity which modern music possesses, in consequence of its being written in definite keys, thereby conforming to certain defined arrangements of tones and semitones in the diatonic scale.

Tondino (Ital.). In Architecture, the same as Astragal.

Tone (Gr. τόνος, from τείνω, *to stretch*). In Music, this word has several meanings.

1. It refers to the quality of sound emitted by any musical instrument; thus, we say a pianoforte or a violin has a *good* tone, a *powerful* tone, a *soft* tone, a *sweet* tone, &c.

2. We speak, in common language, of musical tones as synonymous with musical sounds.

3. A tone is the musical interval comprised between two sounds, whose vibrations are in the ratio of 8 : 9.

Tone. In Physiology, a degree of firmness and tension in certain soft tissues, as contradistinguished from *flabbiness*: it is commonly applied to the muscles, in which the *tone* depends on a state of passive contraction, dependent on the connection of their nerves with the myelon, and which is lost when that connection, or the myelon itself, is destroyed.

Tones, Ecclesiastical. In Music, the eight modes, now generally called the Gregorian Chants, in which the psalms of the Catholic Church are intoned. Pope Gregory the Great has been considered the inventor of them.

Tongue (A.-Sax. tunga; Goth. tuggo; Ger. zunge; Celtic dingua, standing to the Lat. lingua, in the relation of Lat. lacryma, Fr. larme; to Gr. δάκρυμα, Goth. tagr, Eng. *tear*). In Anatomy, the organ of taste; a soft fleshy viscus, movable in all directions, composed of muscular fibres covered by a membrane, upon which, especially at the tip and sides, are numerous nervous papillæ. The tongue is largely supplied by blood-vessels, its arteries being branches of the ranine and labial, and its veins emptying into the great linguals which proceed to the external jugular; the nerves come from the fifth, eighth, and ninth pairs. The tongue performs important functions, not only in tasting, but in articulating, and in eating, chewing, or swallowing food, and in receiving drink.

Tongue. In Architecture. [Groove.]

Tonic (from *tone*). In Music, the principal or key-note of the scale. It is the chief sound upon which all regular melodies depend, and in which they, or at least the bass accompanying them, should usually terminate.

Tonics. Medicines which gradually and permanently increase the tonicity of the system, strengthening and invigorating it when in a debilitated condition; they increase the appetite, assist digestion, and thus, by increasing nutrition, give firmness to the muscular and circulating system. The principal tonics are to be found among the vegetable astringents and bitters, the mineral acids, and the preparations of iron.

Tonka or Tonquin Bean. The fruit of the *Dipteryx odorata*. It is used as a perfume, especially for snuff; its odour, resembling that of new hay, is derived from a concrete volatile oil which chemists have termed COUMARIN, or *Tonka-Camphor*. [DIPTERYX.] A similar substance may also be extracted from the flowers of Melilot (*Melilotus officinalis*). [MELILOTUS.]

Tonnage. This word implied originally the number of tons weight which a vessel might safely carry. It is now the gauge of a ship's dimensions, and the standard for tolls, dues, &c. It is so important a subject in its bearing on all matters of mercantile marine, that some detail of the mode of admeasurement appears requisite. Prior to January 1836, the rule established by Act of Parliament for the measurement of the tonnage of ships was founded on erroneous principles, and led to the most mischievous consequences.

By considering the breadth and depth as nearly the same, the rule implied the square of the breadth; and hence increasing the breadth of a vessel increased her *nominal* tonnage for the payment of dues more than it increased her real capacity. Under this pernicious system, vessels came to be built narrow and deep; and were thus not only less efficient, but highly dangerous. In 1823 a committee, of which Dr. T. Young was chairman, proposed to measure the internal capacity by taking the breadth and depth at each quarter of the length; but for some reason no step was taken. In 1832 another committee was appointed to consider the subject; and they concluded their labours in 1834 by recommending the method of Mr. Riddle, of the Royal Hospital, Greenwich. Mr. Riddle inferred that since a great number of direct measures for capacity would afford a result very near the truth, an approximation might be obtained by means of a smaller number of measures, provided additional weight was given in the calculation to those dimensions which extend through a greater part of the hull. He obtained the multipliers of these dimensions—the midship breadth and depth—by trial, from the vessels measured for the guidance of the committee; and the method is therefore founded on an arithmetical fact. Having been adopted by all vessels registered under the Board of Trade as the basis for dock dues, &c., this system of measuring tonnage was enacted by Parliament in 1835 (to the great improvement of shipbuilding), and, with much modification, made yet more compulsory by the Merchant Shipping Act of 1854. The rule, briefly expressed, as laid down in the Act of 1854 (17 & 18 Vict. c. 104 ss. 20–29), is as follows:—

All dimensions to be taken in feet and decimal parts of feet.

1. Measure the length on the *tonnage deck* from the inside of the inner plank at the side of the stem to the inside of the midship stern timber.

The *tonnage deck* is the upper deck of ships with less than three decks; the second deck from below if there be three or more decks.

2. Divide the length of the tonnage deck into equal parts as follows:—

If not exceeding	50 feet long,	into	4	parts.
,, ,,	120	,, ,,	6	,,
,, ,,	180	,, ,,	8	,,
,, ,,	225	,, ,,	10	,,
Above	225	,, ,,	12	,,

3. At each point obtained by rule 2, compute the transverse area of the ship, by taking the depth below the tonnage deck from a point one-third of the round of the beam below such deck to the upper side of the floor timber at the inside of the limber-strake. Next ascertain the width at three points, found by dividing the depth into four parts if such depth amidships do not exceed sixteen feet, or at five points, the divisions between six parts, if it do; as well as at the top and bottom of such line of depth. Number these breadths 1, 2, &c. from above. (*a.*) In the case of the line divided into four, multiply the second and fourth breadths by four; and the third by two: add these products to the sum of the first and fifth breadths; multiply the total by one-third of the common interval between the breadths: the product shall be deemed the transverse area. (*b.*) In the case of the line of depth divided into six, multiply the second, fourth, and sixth depths by four; and the third and fifth by two; to the sum of these products add the first and seventh breadths; multiply the total sum by one-third the common interval between the breadths: the result shall be deemed the transverse area.

4. Having found these transverse areas, number them 1, 2, &c. from the bow; No. 1 being at the extreme bow end of the line of length and the last number at the extreme stern end of such line. Then multiply every even-numbered area by four, and each odd-numbered (except No. 1 and the last) by two. To the sum of these products add the first and last areas if they yield anything. Multiply the total by one-third the common distance between the areas, and divide the product by 100. The quotient shall be the tonnage under the tonnage deck and the register tonnage, subject to certain additions and deductions, of the ship.

In vessels with a poop or a break in the upper deck, measure the mean horizontal area and height of such poop; multiply these together, and divide by 100, and add the result to the former tonnage.

If a vessel have more than three decks, the tonnage due to each between-deck space above the tonnage deck shall be found, as in the case of the poop, and added. In open vessels, the depth is measured from the upper edge of the upper strake.

In vessels propelled otherwise than by sails, the tonnage due to the content of the engine room, found by multiplying together the length, breadth, and height, and by dividing the product by 100, is to be deducted from the gross

tonnage. The space occupied by a screw shaft is to be included as part of the engine-room.

The relative capacities of ships are determined very nearly by this method, i.e. within little more than four or five per cent. generally; though, in extreme cases, the difference may amount to ten or twelve per cent. Even this, however, is insignificant, as compared with the usual errors of the former method. The divisor by which cubic content is reduced to nominal tonnage has been adopted merely in order that, while the reputed tonnage of most kinds of vessels would be corrected by the new rule, the total registered tonnage of the kingdom might remain unaltered. By the new method the dues paid on tonnage are proportioned to the capacities of the vessels; and as no advantage is gained in these respects by defective forms, a marked improvement in merchant vessels has followed the passing of the Act.

The new measurement is universally adopted for vessels registered under the Board of Trade; each ship being required (to be deemed a British merchant ship) to have her number and tonnage carved or painted conspicuously on her main beam; but pleasure yachts still, for the most part, cling to the O.M. or old measurement.

Tonnage and Poundage. *Tonnage* was a duty upon all wines imported over and above *prisage*. [PRISAGE.] *Poundage* was a duty imposed ad valorem at the rate of twelve pence in the pound on all other merchandise whatever. These duties were granted to the crown by parliament, at first periodically, then annually, till the reign of Charles I., who collected them for fifteen years without the consent of parliament; a right formally renounced by stat. 16 Ch. I. c. 8. After the Restoration, these duties were continued by parliament from time to time till the year 1787, when they were merged in the general customs duties by the first Customs Consolidation Act (27 Geo. III. c. 13).

Tonsillitis. Inflammation of the tonsils. [QUINSEY.]

Tonsils (Lat. tonsilla, dim. of tonsa, part. of tondeo, *to shear* or *cut off*). An oblong suboval gland on each side of the fauces, and opening into the cavity of the mouth by several large ducts.

Tonsure (Lat. tonsura, from tondeo, *I shave*). The *crown* or space on the top of the head kept shaven by persons in orders, or belonging to religious bodies in the Roman and other churches. Tonsure is said to be of two kinds; one denominated after St. Paul, across the whole front of the head from ear to ear, in use in the Eastern churches, (and those of Britain and Ireland); the other from St. Peter, the ordinary Romish. Tonsure was first rendered obligatory by the Fourth Council of Toledo, A.D. 633. The tonsure is larger in proportion to the rank of the person in the church. It is supposed to represent the crown of thorns placed on the head of Christ when before Pilate.

Tontine. At or about the conclusion of the seventeenth century, one Tonti, a Neapolitan, suggested to the French government a new method of raising money, on the joint lives of a number of subscribers to a government fund. The suggestion was neglected in France, but adopted in England, and for some time joint annuities, under the name of *tontines*, from the inventor, were a customary means of borrowing money.

A tontine is an ingenious scheme in which the prudential practice of securing a fixed provision on the basis of a government obligation is coupled with the speculative tendency of considering one's own chance of life better than that of one's neighbour. A number of persons join in equal or varying shares towards a government loan, and receive a proportionate annuity, with a right of survivorship, the last survivor receiving the whole sum annually paid, or, as is generally the case, such a proportion of the whole sum as has been determined at the time in which the tontine was created. Thus, if a thousand persons subscribed a fund sufficient, on calculations made by government as to the expectation of loss, to secure annuities of 100*l*. to each subscriber, the last survivor would on the first hypothesis receive 100,000*l*. a year, or whatever sum, say 10,000*l*. or 20,000*l*., was agreed on when the tontine was created, as the annuity of the last survivor.

Tontines have long ceased to be favourite schemes of government. On the whole, the state lost considerably by the arrangement. This was due to two causes at least. The calculations made as to the probable duration of human life, having been taken on the whole from insurance tables, erred on the side of deficiency, and thus, on the whole, the ordinary annuitant, who would seldom purchase unless with a good prospect of life, gained considerably. Again, tontines were frequent subjects for investment on the part of speculators and even of companies. To make them as profitable as possible, agents were despatched over the whole country, to search out families noted for longevity, and select from them individuals of the healthiest frame and most temperate habits. As a consequence, the investment in tontine funds was advantageous to the purchaser and a loss to government. It may be observed that the dead weight annuity of the Bank of England, which expires in 1867, is in principle a tontine on a gigantic scale, the annuities payable in 1823 having amounted to upwards of 5,000,000*l*., and the Bank having stipulated to satisfy them in consideration of an annual payment of 585,740*l*. for forty-four years commencing on April 5, 1823.

Toon Wood. The wood of *Cedrela Toona.*

Toot Plant. A poisonous New Zealand shrub, *Coriaria ruscifolia.*

Toothache-tree. One of the names of the *Xanthoxylon fraxineum.*

Toothing. In Architecture, bricks alternately projecting at the end of a wall, in order that they may be bonded into a continuation of it when the remainder is carried up.

Top (A.-Sax.). In Naval language, a small light platform around the lower mast-head.

Top, Spinning. A well-known toy. The steady motion which a well-spun top soon acquires suggested to Mr. Sisson, about eighty years ago, the employment of a mirror placed upon it at right angles to its axis, as an artificial horizon which might probably be used at sea; and on sending out the first of the late polar expeditions, the attention of Mr. Troughton was turned to the subject. But though useful observations might have been made on land with the instrument which he constructed, it was not found at sea to give results of any practical value. More recently Mr. Piazzi Smyth has constructed on this principle a contrivance which he calls a *free revolving stand*, and which has been used with some success.

Top-and-Butt. An arrangement of the planks of the outside by which economy of wood is secured. They are so bolted on that two rows produce a straight band.

Top-mast. The second mast from the deck, being above the lower mast, and below the topgallant mast. It is sustained by a fid, through its base, which rests on the trestle-trees, steadiness being maintained by the cap on the lower mast-head, the topmast shrouds, stays, and backstays.

Toparchy (Gr. τοπαρχία, from τόπος, *a place*, and ἄρχω, *I rule*). In Ancient History, a small state or lordship consisting only of a few cities or towns; or a petty country under the sway of a toparch. Thus Judæa was anciently divided into ten toparchies.

Topaz. A silicate of alumina containing fluorine. It occurs crystallised and in water-worn pebbles, and is harder than Quartz, but less hard than Ruby. It is limpid and transparent, colourless or yellow, or of a wine-colour, blue, green, &c.

When heated, the Brazilian Topaz becomes rose-red, and is sometimes in this state passed off as a Ruby; the Saxon Topaz loses its colour by heat. When without flaws and of a good colour, it is much employed in jewellery. The Saxon is usually paler than the Brazilian, which often has a pinkish hue; the Siberian Topaz is usually colourless, and the Scotch has a blue tinge. The name is derived from Topazos, an island in the Red Sea, whence the ancients procured their Topazes. (Bristow's *Glossary of Mineralogy*, p. 383.)

Topazine Quartz. [False Topaz; Smoky Quartz.]

Topazolite. A variety of lime-Garnet, found in translucent, honey-yellow crystals (which are sometimes of an olive-green colour), at Mussa in Piedmont.

Topchains. On Shipboard, chains used in action, by which the lower yard is hung in case of the slings being shot away.

Topgallant. That which is next above the topmast.

Tophet. Tophet, it would seem, was originally a garden or pleasance of the Jewish kings, which some among them defiled by the worship of Baal and by human sacrifices offered to Moloch. Afterwards the name was used to denote any polluted or unclean place.

The name is derived by some from Heb. toph, *a drum*, on account of the beating of drums and other instruments by which the cries of the children sacrificed to Moloch were stifled, or which were used there on festive occasions.

Tophus (Lat.). A soft tumour upon a bone, also a term used to designate gouty deposit in the smaller joints.

Tophus. A name given to porous deposits of calcareous matter from water. Probably the term *tufa* or *tuff*, which is ordinarily used to denote such deposits, is a corruption of the word *tophus*.

Topiary Work (Lat. ars topiaria). In Horticulture, this expression is used to designate the fanciful shapes formerly given, by cutting and trimming, to arbours, hedges, and trees in formal gardens. Topiary work is now happily obsolete, and ornamental trees are suffered to grow without being tortured into the unseemly forms which once were given to them. The term does not include such moderate knife-pruning as may be designed to give finish to a naturally graceful shape, but is applied to such cutting (clipping) as gives an artificial form or outline.

Topics (Gr. τοπικός, from τόπος, *a place*). In Rhetoric. By abstracting from a proposition which conveys a truth in the concrete (i.e. respecting certain circumstances expressed in the terms of the proposition) a portion of those circumstances denominated accidental, we arrive at the same truth in the abstract, or (in stricter language) in a more widely applicable form, accommodated to many different sets of accidental circumstances. Thus, for example, in jurisprudence, from an investigation of the truth in various insulated cases in which a too strict application of legal principles has been attended with evil effects, we deduce the general truth that such application is so attended; or, in the proverbial phrase, 'summum jus summa injuria.' Among the helps employed by the ancients in their favourite study of rhetoric was the collection and arrangement of a great variety of such general truths, according to the several sciences or subjects to which they belonged. These they termed *topoi*, or places; from which the modern term *topic* is derived. They considered it useful for the student in rhetoric to have at hand, by means of his memory, these compendious expressions of universal sentiment, and the general reasonings or declamations applicable to each of them, in order to employ them for particular use by performing the converse of that operation by which they were arrived at; viz. clothing them with the particular circumstances of the case. Thus the topos just cited might be useful to the forensic orator; it affords a subject for reasoning and

declamation applicable to a great number of individual instances. Many of these topics answer to what in modern phrase we should term *axioms*; and, indeed, some of the axioms of pure mathematics are enumerated by Aristotle among the topics which are proper to every species of oratory.

Topography (Gr. τοπογραφία). Strictly the description of a place, or the science of describing places (distinguished from *chorography*, or the description of a district, and from *geography*, the description of the earth).

Topping Lift. On Shipboard, tackle for raising the outer end of a gaff or boom.

Toptimbers. In the ribs of a ship's side, those pieces which are next above the futtocks.

Torbane Hill Coal or **Torbanite.** A kind of Cannel Coal found at Torbane and other places near Bathgate in Linlithgowshire, in the upper coal-measures of Scotland, where it sometimes passes into Blackband Ironstone and into ordinary Cannel. This mineral is the most valuable coal hitherto discovered for making gas and paraffine. (Ure's *Dict. of Arts, &c.*)

Torberite. A Mineralogical synonym for Copper-Uranite.

Toreumatology (Gr. τόρευμα, *embossed work*, and λόγος). This word signifies either the science or art of sculpture, or a description of ancient and modern sculpture and bas-relief.

Toreutic (Gr. τορευτικός, *belonging to work in relief*). In Sculpture, a term applied to such objects as are executed with high finish, delicacy, and polish; but properly to all figures in hard wood, ivory, &c. and often restricted to metallic carvings or castings in basso-rilievo. But in its widest sense it signifies sculpture in any style, or in any material, whether modelled, carved, or cast.

Toria. An Eastern name for *Sinapis glauca*, a species extensively cultivated in India for the oil obtained from the seed.

Tormentil Root. The root of the *Potentilla Tormentilla*. It is occasionally used in medicine as an astringent.

Tornado (Span.). A violent hurricane or gust of wind, which, arising suddenly from the shore, veers round to all points of the compass, and indeed has been described as blowing from all points at once. Tornadoes are usually accompanied with thunder storms, and are generally of short duration. They are frequent in the Chinese seas and the West Indies. [Storm.]

Tornatella. A genus of oval marine Univalves belonging to the *Plicaceæ*, found fossil in the oolite and superjacent strata. Recent tornatellæ are found in shallow water, creeping upon and furrowing the sand.

Torpedo (Lat.). A genus of Cartilaginous fishes, separated from the *Raiæ* of Linnæus on account of the circular form of the body, and more especially from the presence of the electrical organs on which that form of the body mainly depends. Violent shocks are experienced on touching the living and active torpedo. It is probable that it exerts its electrifying or benumbing powers in order to secure its prey; and it is certain that the same power is employed in defending itself against assailants, to whose assaults it would be otherwise more exposed than are the ordinary rays; for the torpedo has a smooth skin, and is not defended by the spiny tubercles, or barbed and pointed bony weapons, with which the non-electric rays are provided.

Torpedo. In Nautical language, the name applied to certain vessels constructed for navigating under water, the power of sustaining life and of moving the structure being derived from compressed air. Various designs of this class have at different times been brought to the test of experiments, but no practical results have hitherto followed.

The word has in recent years been also used to designate certain submerged bombshells, which are placed in the way of ships, to be fired beneath them. They were used during both the Russian and American wars. The torpedoes are of two kinds, one self-acting, which is equally dangerous to friend and foe, and presents the especial difficulty that it is no easy matter to fish it up without an explosion; the other class are fired by electricity. The self-acting, of which there are many varieties, may in general terms be described as consisting of an inverted cone of thin iron, containing gunpowder, in communication with which is a small case of lime. In this lime is a glass tube of sulphuric acid, which is connected with an iron rod projecting from the top of the torpedo: on a ship striking this rod, or any branch rod attached to it, it breaks the glass tube: the acid fires the lime, and the heat explodes the powder.

The electric torpedoes are of two sorts; one in which two observers, at separate points in the wire circuit connecting the torpedo with the electric battery, look along lines intersecting at the machine. Each maintains the electric connection at his station so long as an enemy's ship is over his line of view, and when both observers simultaneously connect, the electric circuit becomes complete, and the powder is blown up, the ship being of necessity where the lines of sight cross. The remaining sort of electric torpedo is self-firing. A covered wire is laid from a battery on shore to the outside of a metal cylinder in the middle of the torpedo. The other pole of the battery is connected by a wire with the water. An iron rod rises from the centre of the torpedo, with attached feelers. Its lower end has a certain play within the metallic cylinder. When an enemy's ship approaches, the shore communication is made complete by attendants on the land: if the ship strike the feel-rod, the lower end is brought against the side of the cylinder, and from the strong conductivity of the water the entire circuit is immediately formed, when the apparatus explodes. The electric torpedoes are best adapted for rivers or parts near the shore.

Three kinds of self-acting torpedoes were

employed by the Confederates at Fort Wagner, which are fully described in General Gillmore's *Artillery and Engineer Operations against Charleston.* Being injudiciously placed, they were as great an impediment to the Confederates as to the attacking Federals, entirely hindering them from issuing out to attack the besiegers, who could thus continue their works in perfect security from sorties.

Torpidity. [HYBERNATION.]

Torques. In Antiquities, the Latin name for a chain or collar formed of a number of small ringlets interlaced with each other, framed of metal, and worn round the neck. No ornament perhaps was of more early or general use. It was in use among the Greeks and Romans, but peculiarly among the Celtic nations. The legends respecting the torques of the Gauls who invaded Rome are well known. T. Manlius Torquatus is said to have derived his surname from having vanquished a Gaulish warrior, whom he deprived of his chain. (Livy, lib. vii. ch. x.) No relic is more commonly found in this country by antiquarian explorers. Boadicea wore a large golden torques. (Dio. Cass. lxii.) See the *Archæologia*, vol. xiv. p. 97 and passim, for descriptions of particular specimens.

Torrefaction (Lat. torrefacio, *I roast*). The operation of roasting ores to deprive them of sulphur, arsenic, or other volatile ingredients. When drugs are highly dried, or partially toasted or roasted, they are also said to be torrefied.

Torrelite. A name for Columbite, after Dr. J. Torrey.

Torreya (after Dr. Torrey, an American botanist). A genus of *Taxaceæ*, to which the name of Stinking Yews has been given, from the disagreeable smell given off by the leaves and wood when bruised or burnt. They are small evergreen trees of North America, China, or Japan, and grow from twenty to fifty feet high with two-ranked linear or lanceolate leaves and diœcious flowers. The fruits are drupaceous. The timber of *T. taxifolia* and *T. myristica* is heavy and close-grained, but has a disagreeable smell. The kernels of the seeds of *T. nucifera* yield an oil which is used for culinary purposes, but the kernel itself is too astringent to be eaten.

Torricellian Vacuum. In Physics, the vacuum produced by inverting a tube of sufficient length, filled with mercury or any other fluid, in a vessel containing a portion of the same fluid, and allowing the fluid in the tube to descend until its weight is counterbalanced by that of the atmosphere. In this manner the first barometers were formed by Torricelli, and thence called *Torricellian tubes.* [BAROMETER.]

Torrid Zone. In Geography, the zone of the earth included between the tropics of Cancer and Capricorn. It extends from the equator, on both sides, to the parallel corresponding to the sun's greatest declination, about 23½ degrees. [ECLIPTIC ZONE.]

Torsion (Lat. tortio, from torqueo, *I twist*). In Geometry, the departure of a curve from the plane containing three consecutive elements. The angle $d\sigma$ between two consecutive osculating planes, is termed the *angle of torsion*, and the *torsion* itself, or second curvature, as the French term it, is measured by the quantity $\frac{d\sigma}{ds}$, where ds is the element of the arc of the curve. The inverse of this quantity, viz. $\frac{ds}{d\sigma}=r$, is called the *radius of torsion.* The angle of torsion of a curve is always equal to the angle of contact of the cuspidal edge of the polar developable, and the angle of torsion of the latter is equal to the angle of contact of the original curve. The radii of torsion and curvature, however, have not the same reciprocal relations, since the arcs of the two curves are in general unequal. [POLAR DEVELOPABLE.]

Some continental writers have also considered the departure of a curve from the osculating sphere determined by four consecutive points, to which they have given the name *spherical torsion.* (Grunert's *Archiv der Math.* th. 19.)

TORSION. In Mechanics, the twisting or wrenching of a body by the exertion of a lateral force. If a slender rod of metal suspended vertically, and having its upper end fixed, be twisted through a certain angle by a force acting in a plane perpendicular to its axis, it will, on the removal of the force, untwist itself, or return in the opposite direction with a greater or less velocity, and, after a series of oscillations, will come to rest in its original position. The limits of torsion within which the body will return to its original state depend upon its elasticity. A fine wire of a few feet in length may be twisted through several revolutions without impairing its elasticity; and within those limits the force evolved is found to be perfectly regular, and directly proportional to the angular displacement from the position of rest. If the angular displacement exceed a certain limit, the particles of the body will be wrenched asunder; or if the elasticity be not perfect (as in a wire of lead, for example) before disruption takes place, the particles will assume a new arrangement or *take a set,* and will not return to their original position on the withdrawal of the disturbing force.

The resistance which cylinders or prisms formed of different substances oppose to torsion, furnishes one of the usual methods of determining the elasticity and strength of materials; and the property which a metallic wire or thread stretched by a small weight possesses of becoming twisted and untwisted in a series of isochronous and perfectly regular oscillations, has been ingeniously applied in the torsion balance to the measurement of very minute forces, and thereby to the establishment of the fundamental laws of electricity and magnetism, and to the determination of the mean density of the earth. [BALANCE OF TORSION.]

The laws of torsion have been experimentally investigated by Coulomb in a variety of substances. The method which he employed consisted in attaching a body of given form and dimensions to the extremity of the wire, and, after twisting it through a certain angle, abandoning it to the action of the force evolved, and observing the time of the oscillations. The following general laws were found to hold good:—

1. On loading a wire or thread with different weights, it will settle in different positions of stable equilibrium; i.e. an index attached to the weight will point in different directions if the weight be varied, and the angular deviation may amount even to a whole circumference.

2. The oscillations are isochronous.

3. The time of oscillation is proportional to the square root of the weight which stretches the wire.

4. The time of oscillation is as the square root of the length of the wire.

5. The time of oscillation is inversely as the square of the diameter of the wire.

From the second of these laws it follows that when the wire is twisted round from the position of rest, the force with which it tends to return to that position is proportional to the angle to be described in order to attain it. For it is a general result of mechanics, that all motions produced by forces acting according to this law have the property of isochronism: i.e. the oscillations are performed in equal times, whatever be the length of the arc. This fundamental property is usually enunciated by saying that the force of torsion is proportional to the angle of torsion.

Let F denote the force of torsion, measured by the weight which it would be necessary to apply by means of a pulley to a point p, situated at the unit of distance (one inch) from the axis of the wire, and invariably connected with it, to cause the point p to describe an arc of a circle equal in length to the unit of distance; then, by the property enunciated, the force which must be applied at p in order that the point may describe any arc ϕ is expressed by $F \times \phi$.

On this principle of the proportionality of the impelling force to the angle of deviation, the problem of determining the time of an oscillation is solved. Suppose a body of any form attached to the extremity of a slender wire the weight of which, when compared with that of the body, may be neglected, and let dm be an element of mass, r the distance of dm from the axis of the wire, and T the time of an oscillation; the solution of the problem gives—

$$T = \pi \sqrt{\left(\frac{\int r^2 dm}{F}\right)} \text{ or } T^2 = \pi^2 \frac{\int r^2 dm}{F}$$

where the integral $\int r^2\, dm$ is the *moment of inertia* of the attached body. If the body be a cylinder whose axis coincides with that of the wire, and if a denote its radius and M its mass, then $\int r^2\, dm = \frac{1}{2} M\, a^2$; or, expressing the mass in terms of the weight, and observing that if the weight be denoted by P, and the accelerating force of gravity by g ($=32{\cdot}1908$ feet or $386{\cdot}2894$ inches in a second), we have $P = Mg$, $\int r^2 dm = Pa^2 + 2g$. Hence the expression for the time becomes $T = \pi a \sqrt{\frac{P}{2gF}}$.

If the attached body were a slender cylindrical needle suspended horizontally by its middle to the wire, we should, on denoting its length by $2l$, have $\int r^2 dm = \frac{1}{3} M l^2$; whence

$$T = \pi l \sqrt{\frac{P}{3gF}}.$$

The following results are deduced from the formula: 1. The force of torsion is independent of the weight which stretches the wire, or F remains constant while P is varied. For suppose P to become P′, and let T′ be the corresponding time of oscillation, and F′ the corresponding force; we have then

$$T^2 = \frac{\pi^2 a^2 P}{2gF}, T'^2 = \frac{\pi^2 a^2 P'}{2gF'};$$

whence $T^2 : T'^2 = P F' : P' F$. But, by the third experimental law, $T^2 : T'^2 = P : P'$; therefore $F' = F$.

2. The force is inversely as the length of the wire. For, supposing P to remain constant, we have $T^2 : T'^2 = F' : F$. But, by the fourth experimental law, $T^2 : T'^2 = l : l'$; whence $F' : F = l : l'$.

3. The force is proportional to the fourth power of the diameter of the wire. Let there be two wires of the same substance, but of different diameters, D and D′, and stretched by the same weight P; and let T and T′ be the corresponding times. By the fifth experimental law, we have $T : T' = D'^2 : D^2$. But it has been shown that $T^2 : T'^2 = F' : F$; therefore $F : F' = D^4 : D'^4$.

For the demonstration of the fundamental formula, viz. $T^2 F = \pi^2 \int r^2 dm$, see Coulomb, *Théorie des Machines Simples*, or Biot, *Traité de Physique*, tom. i.

Torso (Ital.). In Sculpture, a statue of which nothing but the trunk of the human figure remains, as for instance the celebrated Torso of Apollonius, now in the Vatican.

Tort (Fr. *wrong*, from Lat. tortus, *twisted*). In Law, this word signifies injustice or injury. 'Actions founded on *torts*' are such actions as are brought for the redress of wrongs not arising from breaches of contract; they are sometimes described as actions *ex delicto*.

Tortoise. This name is usually applied to species of that division of the Linnæan genus *Testudo* including the terrestrial Chelonians, to which the generic name is now limited. [TESTUDO.]

Tortoise Plant. *Testudinaria elephantipes.*

Tortoise Shell. The name given to the horny scutes or plates of the sea turtles; and in particular to those of the hawk's-bill turtle, *Chelone imbricata.*

Tortrices (Lat. torqueo, *I wreathe*). The name of a tribe of nocturnal Lepidopterous insects, comprising those the larvæ of which live concealed in leaves, which they roll around them for the purpose.

Torture (Lat. torqueo, *I twist* or *torment*). In a Legal sense, the infliction of pain on an accused person in order to extort an avowal of guilt, or revelation of accomplices. Such a practice is sufficiently common among all half-civilised nations; but the Greeks and Romans were perhaps the first who introduced it as a part of their regular proceedings in criminal cases. Both at Athens and Rome torture was, however, considered as applicable only to extort evidence from slaves: towards them it was used profusely; and it was, in fact, a usual occurrence to order a whole family of slaves to the torture, in order to extract revelations where a crime had been committed, as, for instance, the murder of the master. Cicero, in several passages, condemns the use of torture; and Ulpian (Lex i. *De Quæstionibus*) says, 'Res est fragilis et periculosa, et quæ veritatem fallit, nam plerique patientiâ sive duritiâ tormentorem ita et tormenta contemnunt, ut exprimi eis veritas nullo modo possit; alii tantâ sunt impatientiâ ut quid vis mentiri quam pati tormenta malint.' (As to the torture at Rome, see Gibbon, vol. ii. p. 59, 4to ed.) Notwithstanding these recorded opinions of the highest luminaries of ancient jurisprudence, torture was adopted along with the rest of the process of the civil law in most European countries. [For its use in France, see QUESTION.] The general principle of the civilians was, that it could not be used unless *vehement suspicion* warranted its application. But no very definite meaning was attached in practice to these words; especially in Germany, where the abuse seems to have been carried to the greatest extent by the ignorant and cruel tribunals of her smaller states. When Howard visited the prisons of that country (about 1770), it was still in general use. (*Account of Prisons.*) The writings of various philosophical authors of the eighteenth century, especially Voltaire, Thomasius, and Beccaria (whose short treatise, *Dei Delitti e delle Pene,* obtained such singular notoriety), effected much towards bringing its employment into disrepute; but its general abolition can only be attributed to the superior regard for the rights of man introduced everywhere by the agitation of the French revolution. In England, judicial torture was not recognised by the common law (for the peine forte et dure hardly falls within the same definition); and that it was also nearly unknown in practice, in the fourteenth century at least, may be inferred from the reluctance of Edward II. to submit the Templars to torture, which was overcome by the instances of Pope Clement V., and from a curious paper of questions addressed on that occasion by the archbishop of York to some divines, from which it appears that *no torturer could at that time be found in England.* (Raynouard, *Mèmoires sur les Templiers*; Hallam's *Constitutional History.*) The rack is said to have been introduced as an engine of state by the duke of Exeter in the reign of Henry VI. However this may be, during the whole of the sixteenth century we find that the Privy Council assumed and exercised the right to direct torture-warrants to the lieutenant of the Tower and other officers, commanding them to submit to the torture persons accused not only of state offences, but of ordinary municipal crimes, when strong suspicion, but no sufficient evidence, existed. Torture warrants were also issued, not by the council, but under the sign manual only. During this period the council seems, in fact, to have acted as a supplementary tribunal in aid of the regular courts, for the purpose of extorting discoveries of criminal offences. The instances of torture of seminary priests, &c., in Elizabeth's reign, have been often cited; but it is not so generally known that the practice was not confined to accusations of treason and sedition, but extended to other cases. (Jardine's *Reading on the Use of Torture in England,* 1837.) Under James I. and Charles I. torture seems to have become less frequent, and to have been only employed in state offences; and this, perhaps, explains the well-known answer of the judges to Charles's question respecting Felton, the murderer of the duke of Buckingham, that he ought not to be tortured, 'for no such punishment is known to our law.' The last recorded case is that of William Archer, 1640; and as in that year the Act for the abolition of the Star Chamber granted a habeas corpus to all persons detained on warrants from the Privy Council, torture must then have been virtually abolished. In Scotland, it was so in the seventh year of Anne. For the frightful systems of torture employed by Italian tyrants, see Sismondi, *Histoire des Rèpubliques Italiennes,* iv. 282. A complete set of instruments of torture is, or was lately, shown at Ratisbon.

Torus (Lat.). In Architecture, a large moulding used in the bases of columns, the profile of which is semicircular.

TORUS. In Botany, the axis on which the various floral whorls within the calyx are seated. It is the same as Thalamus.

Tory. A well-known party name in English History. While the Presbyterian covenanters who rose against the government of Charles II. received the name of WHIGS, that of *Tory* was given to Popish outlaws who found a refuge in the bogs of Ireland, and who were afterwards called *Whiteboys.* Hence the name was applied to Englishmen who refused to concur in excluding a Roman Catholic prince from the throne. (Macaulay's *History of England,* vol i. ch. iii.)

Down to the time when Hume wrote his *Essay on the Parties of Great Britain*, the conduct of the two great parties in the state (the Whigs and Tories) had been so vague and undetermined, as to have led him to declare his utter inability to tell their nature, pretensions, and principles. Of late years, the word *Tory* has been gradually displaced by *Conservative*. This term was originally assumed in contradistinction to *Destructives*, a name by which the more violent reformers came to be designated by their enemies; and it is now understood as referring to the whole Tory party, but more especially to what may be called the more liberal portion of that party.

Tosorthrus. [SESOSTRIS.]

Totipalmates (Lat. totus, *entire*, and palma, *a palm*). The name of a tribe of *Palmipedes*, or swimming birds, including those in which the hinder toe is enveloped in the same web with the three anterior toes.

Toucan or **Tucan.** [RHAMPHASTOS.]

Touch (Fr. toucher, Ger. ticken, akin to Lat. tango, te-tig-i, Gr. θιγγάνω, ἐ-θιγ-ον). In Medicine. The belief in the possibility of curing various maladies by the touch has produced many superstitions. Plutarch attributes singular virtues to the touch of King Pyrrhus of Epirus. According to Suetonius, Hadrian and Vespasian had the power of curing certain diseases in the same manner. In what period the opinion respecting the virtue of the touch of the kings of France and England in curing epilepsy, scrofulas, &c. had its origin, it is difficult to ascertain. André Dulaurent, chief physician of Henry IV. of France, published a treatise on the subject. The ceremony of touching, by the kings of France, was practised at the four great feasts of the year; sometimes as many as 1,500 were touched at a time. By an odd etiquette, the Spaniards had the first rank, then other foreigners, and the French last of all. The formula used at each imposition of the royal hand was, 'Le roi te touche, et Dieu te guérit.' Polydore Vergil attributes this virtue to Edward IV., and all our kings down to the end of the Stuart dynasty touched for the king's evil. Much efficacy has been attributed in different diseases, particularly tumours, &c., to the touch of the hand of a dead body; especially, according to Pliny and various modern authorities, of one who had died violently. Boyle endeavours to explain away part of the miracle by attributing some virtue to the coldness of the application.

TOUCH. In Naval language, the sails are said to *touch* when the wind comes edgeways upon them, and they consequently shiver.

TOUCH. One of the five senses, resident in the nervous papillæ of the skin; it is also the sensibility diffused over the whole body. It is more exquisite in some parts than others.

TOUCH. [SYCEE.]

Touch Needles. Small bars, consisting of gold and silver alloyed with various definite proportions of copper, are thus termed by assayers, who, by comparing their colour and streak upon a piece of hard black stone, such as basalt, with that of alloys of the precious metals, judge of the relative quantity of gold or silver in the latter. Hence also the term TOUCHSTONE.

Touchstone. A name for *Lydian Stone* or *Basanite*. A velvet-black silicious stone or flinty jasper, used on account of its hardness and blackness for testing the relative quantity of gold or silver in alloys of the precious metals. [TOUCH NEEDLES.]

Touchwood. One of the names given to *Polyporus igniarius*. The soft white substance into which wood is converted by the action of *Fungi* is also called *Touchwood*; of this, the ash, especially under the influence of *Polyporus squamosus*, affords good examples. Occasionally, when highly impregnated with mycelium, it has been observed to be luminous. It derives its name from its property of burning for many hours like tinder when once ignited. This decaying condition of wood is sometimes confounded with the powdery snuff-coloured mass into which wood is sometimes converted without the agency of *Fungi*, by a process of chemical combustion distinguished by the name of EREMACAUSIS. When wood is damp, or placed in an atmosphere charged with moisture, the oxygen of the air combines with the hydrogen, and carbonic acid is given off from the residue: and as this action constantly recurs, the texture of the wood is destroyed, and the whole is reduced into a crumbling mass, which contains a proportionally larger amount of carbon than the original wood. It is this evolution of carbonic acid in a damp atmosphere, when in contact with wood, which makes such situations prejudicial to health. This kind of decay, which often takes place in trees when no fungus is present, and which spreads from within outwards like a putrefactive ferment, contaminates the sound tissues which surround it. There is reason, moreover, for believing that the brown condition so common to diseased vegetable cells has a similar origin.

Tourmaline. A name for the more perfect forms of Schorl. It is chiefly composed of silica, alumina, boracic acid, &c., and has been divided by Rammelsberg into five sub-groups, viz. 1. *Magnesia Tourmaline*; 2. *Iron-magnesia Tourmaline*; 3. *Iron* or *Black Tourmaline*; 4. *Iron manganese-lithia Tourmaline*; 5. *Lithia Tourmaline*. (Bristow's *Glossary of Mineralogy*, p. 385.)

The transparent coloured varieties are sometimes cut into ring-stones, &c. and when reduced to thin slices are much valued for making experiments on the polarisation of light and for analysing the optical properties of other minerals. The Red Tourmaline or *Rubellite* possesses considerable beauty. The finest kinds of Tourmaline are brought from Brazil, Ceylon, Ava, and Siberia. Black Tour-

maline or Schorl is very abundant in the stanniferous granite of Cornwall, in the neighbourhood of St. Austell; and in the granite of Dartmoor in Devonshire, especially near Bovey Tracey.

Tourn. In Law, the tourn was the turn or circuit anciently made twice every year by the sheriff, for the purpose of holding in each hundred the great court leet of the county. The jurisdiction exercised by the sheriff on his tourn extended by the common law to the cognisance of all offences not capital; but sheriffs are prohibited by Magna Charta from holding any pleas of the crown in which they had a pecuniary interest in procuring a conviction; while a better tribunal was at the same time supplied by the establishment of annual circuits. The tourn, though never disallowed by law, has, with the curtailment of its jurisdiction, and the abandonment of the leet as a registry of pledges, long fallen into disuse; and the right of the jury or suitors at the tourn to present nuisances, or convict of minor offences, has, with other functions of courts leet, been transferred to the quarter sessions.

Tournament (Mod. Lat. torneamentum) or **Tourney** (originally derived from Fr. tourner, Mod. Lat. tornare, *to turn*). A military sport of the middle ages, which without doubt arose from the exercises of military training. A *joust* or *just* is, properly speaking, the encounter of two knights in this species of exercise; the *tournament*, an assembly held for the purpose of exhibiting such jousts, or the encounter of several knights on a side. The earlier tournaments were performed with the ordinary weapons of warfare, the lance and the sword; and the combatants had only the strength of their armour to rely on for their defence. It was a recognised custom, according to Meyrick (*Hist. of Ancient Armour*), that whoever slew or disabled an adversary in the tournament was indemnified against all consequences. The account of the tournament held by the count of Chablais in Savoy in honour of Edward I. on his return from Palestine to England, as described by Walsingham, represents a sort of violent mêlée, in which knights, squires, and archers were engaged on both sides, endeavouring to unhorse the riders and overthrow the footmen by every possible means. But in the course of time this chivalric amusement became the subject of minute regulations, which in some degree diminished the danger of the sport. The English *Statuta Armorum de Torneamentis* are assigned by Meyrick to the year 1295. [SAINTE-PALAYE.]

In tournaments, when under the strict regulation of knightly usage, two sorts of arms were employed: those expressly made for the purpose, viz. lances with blunt heads of iron; and the ordinary arms of warfare, termed *armes à outrance*, which were employed only by such champions as were desirous to signalise themselves in more than ordinary degree, and frequently were not permitted by the judges of the tournament. Every knight attending was required to show his noble birth and rank, as a title to admission. These were at first proclaimed by the heralds with sound of trumpet; and hence the word BLAZONRY, which signifies the correct deciphering of the heraldic symbols on a coat-of-arms, is derived by some from the German blasen, *to blow*. Afterwards, when armorial bearings became general, the shield of the knight gave token of his rank and family. The attendance of ladies at the tournament, their distribution of prizes to those who had borne themselves best, arming and unarming the knights, &c., must not be supposed to have been the necessary, or even usual accompaniments of these knightly sports, at least until a later age, when the taste for gallantry, combining with that for show and spectacle, turned these military exhibitions of skill into little more than gorgeous pageants. When we arrive at the reigns of Edward III. and Henry V. we find the jousts usually held in honour of ladies, every knight being bound to possess in reality or in show a dame of his affections, for whose sake all these deeds of chivalry were performed. Sir. S. Meyrick quotes from a manuscript of the reign of Elizabeth the ordinances of jousts, made by John earl of Worcester, constable of England, in the sixth year of Edward IV.; from which it appears that the law of jousts had become by that time the subject of very minute regulation. The prize belonged to him who broke most spears 'as they ought to be broken;' i.e. on the head or body of the antagonist. From Stow we find that the lists erected in Smithfield in 1467, when the Bastard of Burgundy challenged Lord Scales, were 380 feet in length by 260 in breadth; these champions rode at each other two days with spears, and on the third encountered on foot with pole-axes. In the reign of Henry VIII., when the real spirit of chivalry was in its decline, the tournament was invested almost wholly with the character of a court pageant. Admirable accounts of these tournaments will be found in Hall's *Chronicles*. The famous volumes of woodcuts of the same period, styled the *Triumphs of Maximilian*, show that it was as favourite and almost as magnificent a spectacle at the court of Germany. The tragical death of Henry II. of France, in consequence of a blow received in a tournament, was the cause of the gradual abolition of this knightly amusement, which was revived at intervals in court solemnities in the seventeenth century, rather as a memorial of past times than as a subsisting and popular custom. (Sainte-Palaye, *Mémoires sur la Chevalerie*; Turner's *History*, 'Middle Ages,' vol. i. p. 472; *Hist. de l'Acad. des Inscr.* vol. xix.)

Tourniquet (Fr.). A bandage which may be tightened to any extent by means of a screw, so as to exert pressure upon a cushion and compress the arterial trunks to which it is applied: it is chiefly used to prevent hæmorrhage in the operations of amputation.

Tous-les-Mois (Fr. *all the months*). A kind of arrowroot obtained from the tubers of

some South American species of *Canna*—*C. glauca*, *C. coccinea*, *C. Achiras*, and *C. edulis*; the latter, a native of Peru, is believed to furnish the chief portion of that sold in the shops.

Tow (A.-Sax. teogan, Fr. touer). To draw a vessel along by a rope, either from another vessel or from the shore. As the vessel towed affects the motions of the other, much attention is required on her part to second the intentions of the towing vessel.

Towanite. A synonym for Copper Pyrites, after Huel Towan, a Cornish locality.

Tower (Lat. turris). In Architecture, a lofty building, square, polygonal, or circular on the plan, and often consisting of several stories. The tower of a church is that part which contains the bells, and from which the steeple rises.

Towers, Round. Edifices in Ireland varying in height from 80 to 120 feet, cylindrical in shape, with a door 8 or 10 feet from the ground, and with narrow apertures at the top. Antiquaries have been much perplexed in determining their date. They have accordingly been held by some to be temples built by Phœnicians, Persians, Buddhists, &c.; but the question has, in the opinion of some, been set at rest by the researches of Dr. Petrie (*Ecclesiastical Architecture of Ireland* i. 12), who has shown that they are simply detached bell-towers of Christian churches, built so as at the same time to be serviceable for defence in war. (Sir G. C. Lewis, *Astronomy of the Ancients*, p. 442.) The number of these towers in Ireland is sixty-two, and there are two in Scotland, at Abernethy and Brechin.

It is, however, maintained by others, that whatever may have been the purpose for which particular towers were built in Ireland or elsewhere in later times, these edifices are in their original idea phallic [PHALLUS]; that this idea is shown not only by their general form, which is found in countries altogether unconnected with each other, but by the mode in which their summits were finished; that towers unmistakably phallic, and exhibiting a striking resemblance to the Irish towers, are found in Cabul and other Eastern countries; and that these buildings further illustrate the raising of the Ashera on the Altar of Baal, and the combination of the LINGA and YONI in Hindu symbolism; and, further, that this idea furnished the model for church towers in general, these having originally existed in the shape of isolated campaniles (as is still seen in the Italian type), and invariably with a conical summit, which has been developed in the Gothic spire, a termination which, whether added or not, formed, according to A. W. Pugin, a necessary part of the design of all towers of every period of Gothic architecture.

Toxicology (Gr. τό τοξικόν, sc. φάρμακον, literally *poison for smearing arrows with*; λόγος, *a discourse*). Poisons have been divided into *irritants, narcotics*, and *narcotico-irritants*: the first class including those whose sole or predominating symptoms are those of irritation or inflammation; the second, those which produce stupor, delirium, and other affections of the brain and nervous system; and the third, those which are of a mixed character. Many irritants possess corrosive properties, and toxicologists have drawn a distinction between corrosives and purely irritant poisons. This is a modification of Orfila's original arrangement.

The chief effects of *irritants* are upon the alimentary canal, exciting inflammation, and sometimes ulceration, of the tongue, fauces, and œsophagus, difficult deglutition, nausea, vomiting, and heat and pain of the stomach, with more or less tension of the abdomen, and pain on pressure. The sickness is generally accompanied by extreme anxiety and anguish, and the matters vomited consist, in the first instance, of any food that may have been in the stomach, with portions of the poison itself, and afterwards of viscid mucus, often streaked with blood and tinged with bile; the pain afterwards extends throughout the intestines, and mucous, bilious, and often bloody diarrhœa succeeds. The skin is cold and clammy, the pulse quick and feeble, the breathing often difficult, and the countenance expressive of extreme anxiety.

Narcotic poisons induce a train of symptoms of a very distinct character: headache, vertigo, confused vision, stupor, convulsions, paralysis, and coma, are their leading effects; but each particular poison is usually attended by certain peculiarities in the succession, violence, or generic character of the symptoms, which assist the experienced practitioner not only in determining the nature of the poison, but in discriminating between its effects and those of disease.

The symptoms of the *narcotico-acrid poisons* usually consist of those of the two former classes blended, and are often of a very complicated character; for the most part, however, their narcotic and irritant effects appear to be incompatible. In large doses, narcoticism predominates; in smaller, irritation: it is rarely that both are coexistent.

In the following tabular view of the principal poisons of the above classes, the poisons are enumerated, with some additions, in the order in which they are described by Dr. Christison, to whose *Treatise on Poisons*, as also to that of Dr. Taylor, the reader is referred for details which would be quite incompatible with the space which can be allotted to the subject in this work. Under the heads of many of the individual substances mentioned in the following list, we have elsewhere given particulars respecting their composition and properties, and sometimes referred to their toxicological history.

I.—*Irritant Poisons.*

Mineral acids.	Arsenic and its compounds.
Phosphorus.	Mercurial compounds.
Acetic acid.	Salts of copper.
Oxalic acid.	Antimonial poisons.
Fixed alkalies.	Salts of tin.
Nitre.	

Alkaline and earthy chlorides.	Salts of gold.
	Salts of silver.
Lime.	Salts of bismuth.
Ammonia and its salts.	Salts of chromium.
	Salts of zinc.
Alkaline sulphurets.	Lead poisons.
Barytes.	Diseased and decayed animal matter.
Vegetable acrids.	
Cantharides.	Mechanical irritants.
Venomous serpents.	Certain poisonous gases.

II.—*Narcotic Poisons.*

Opium.	Hydrocyanic acid.
Hyoscyamus.	Carbazotic acid.
Lactuca.	Certain poisonous gases.
Solanum.	African ordeal bean.
Chloroform.	

III.—*Narcotico-acrid Poisons.*

Nightshade.	Strychnia.
Thornapple.	Cocculus indicus.
Tobacco.	Upas.
Hemlock.	Poisonous fungi.
Monkshood.	Poisonous grain.
Hellebore.	Alcohol.
Squill.	Ether.
Meadow saffron.	Empyreumatic oils.

Notwithstanding the apparently well marked line of distinction existing between the above classes, experience shows us that the substances arranged under each heading sometimes act very differently. Thus, arsenic and oxalic acid, both irritants, have been known to produce violent narcotic effects, such as coma, paralysis, and convulsions, especially when taken in full dose.

The treatment of cases of poisoning must, of course, vary with the nature of the poison, the quantity taken, and the peculiarities of the individual. In almost all cases, copious vomiting should be excited as soon as possible by tickling the throat and by emetics, especially sulphate of zinc. The latter, in 20-grain doses, dissolved in a little warm water and repeated every ten or fifteen minutes till it freely operates, is generally most effectual. The use of the stomach-pump may in some cases be resorted to. The vomiting should be kept up, and the stomach washed out with bland albuminous or mucilaginous fluids, such as milk, barley-water, flour and water, or thin paste.

The following is a short summary of the antidotes which may be resorted to, in reference to particular poisons. They should, of course, be administered as speedily as possible.

1. For *Mineral Acids*, or *Acetic and Oxalic Acid*:—Chalk, or whiting and water; magnesia and water; soap and water; followed by albuminous diluents, such as milk, and white of egg mixed with water.

2. *Alkalies, Soda, Potash, Ammonia, &c.*:—Vinegar, or any mild acid and water, or even very dilute mineral acids, such as water acidulated by them; olive oil, almond oil.

3. *Arsenic*:—Emetics; and then milk, gruel, thick barley-water, and other similar diluents, in large quantities. Hydrated oxide of iron and hydrate of magnesia have also been recommended.

4. *Corrosive Sublimate*:—White of egg and water; milk and cream; decoction of cinchona; infusion of galls.

5. *Sulphate of Copper*, and other *Cupreous Poisons*:—Sugar and water; white of egg and water.

6. *Antimonial Poisons*:—Warm milk, gruel, or barley-water; infusion of galls; decoction of cinchona.

7. *Nitrate of Silver*:—Copious draughts of warm salt and water.

8. *Sulphate of Zinc*:—Solution of carbonate of soda in water, with milk, and mucilaginous or farinaceous liquids.

9. *Acetate of Lead*:—Emetics; solution of sulphate of soda in water; milk; white of egg and water.

10. *Opium and its Preparations*:—Emetics; strong coffee; dashing cold water upon the face and breast; preventing torpor by forced exercise.

11. *Prussic Acid*:—Ammoniacal stimulants cautiously applied to the nose; ammonia, or sal volatile, in repeated small doses; small doses of solution of chlorine in water; small doses of chloride of lime in water.

12. *Strychnia* and *Vegetable Alkaloids*:—Infusion of gall nuts; decoction of cinchona; emetics.

Toxodon (Gr. *τόξον, a bow*, and *ὀδούς, a tooth*). An extinct genus of quadruped connecting the Pachydermal with the Rodent order, and distinguished by the curved form of all its teeth. The only known species (*Toxodon platensis*, Owen) was as large as the hippopotamus, and appears to have been restricted to the warmer parts of South America.

Toxotæ (Gr. *τοξόται*, from *τόξον*). In Greek Military History, bowmen. In the plays of Aristophanes, the toxotæ mentioned, like the French *archers*, are a kind of police, employed to keep order in the assemblies of the people and on other public occasions.

Trabea (Lat.). In Roman Antiquities, the robe used at first by the kings, but afterwards by consuls and augurs. The purple *trabea* was used only on the occasion of great sacrifices. The second sort, of purple and white, was commonly worn by consuls on state occasions. A third, of purple and scarlet, was the dress of the augurs.

Trabeation (Lat. trabes, *a beam*). In Architecture, the same as ENTABLATURE.

Trace (Fr.; Ital. traccia). In Fortification, the plan of a work.

TRACE. [DESCRIPTIVE GEOMETRY.]

Tracery, Window. The chief distinction between Gothic and all other forms of architecture is furnished by the window. In other styles the window is an excrescence, exhibiting little harmony with the rest of the design. In most of them it is a mere slit or aperture: in Saracenic and other Eastern styles, it is filled sometimes with an intricate network, which may deceive the inexperienced eye by its apparent resemblance to the tracery of Gothic windows,

But in all such cases the effect is much that which would be produced by a stamped pattern, in which the parts between the figures are perforated. Saracenic windows are thus mere reticulations, worked on a single plane, and cannot be placed in the same class with Gothic windows.

The complete idea of Gothic tracery requires not only that the lights and figure (or figures) above them shall be combined by label and arch, with mullions instead of portions of wall, but that the spandrils in the window-head shall be pierced. In the earliest Romanesque styles the window is merely a round-headed aperture, without the slightest attempt at combination; but in later examples these apertures may be found grouped in couplets or triplets. The first sign of the change which led immediately to the developement of tracery is seen in Kirkstall Abbey, where a circle appears above two arches without being combined by any external label or mark to show their relation, the portions of wall between them not being yet reduced into mullions and tracery bars (fig. 1).

Fig. 1.

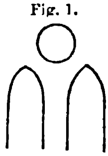


Fig. 2.

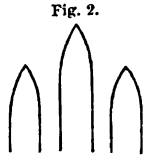


Fig. 3.

The earlier steps in this direction are exhibited in the triple arrangement of lancets (fig. 2), these being followed by the grouping of couplets, first apart (fig. 3), then united by a label over their different members separately (fig. 4), the wall

Fig. 4.

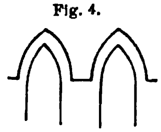


Fig. 5.

between them being then reduced to a mullion (fig. 5), and the couplet itself being afterwards included under one arch (fig. 6). The next step

Fig. 6.

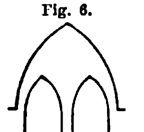


Fig. 7.

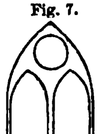
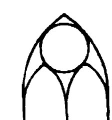


Fig. 8.



was to pierce the space between the couplet and the including arch (fig. 7), by the insertion of a figure which was almost universally the circle, the full developement of the idea of tracery being effected by the piercing of the spandrils (fig 8). It is scarcely necessary to remark that, in their primary developement into full tracery, the couplet and triplet present two very different types; and that while the triplet has influenced comparatively few windows, its own pyramidal form sufficiently filling the window-head (fig. 9), the greater beauties in tracery may be ascribed to adaptations of the couplet (fig. 10); so much so, that in three-light windows (fig. 11), the tracery

Fig. 9.

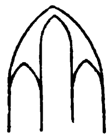


Fig. 10.

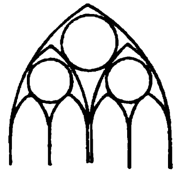
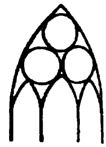


Fig. 11.



is formed by analogy from that which is seen in those groupings of two-light windows which furnish the designs of the most magnificent specimens of the geometrical period. In this style, the typical figure is the circle, pure geometrical tracery being restricted wholly to the use of this figure. This stage was followed by the employment of forms still geometrical, but showing later modifications: as the *vesica* (fig. 12), the *spherical triangle* (fig. 13), and the *spherical square* (fig. 14). Two-light windows in this style exhibit, therefore, simply a circle carried by the arches of the lights, while three-light windows are formed by analogy, three circles occurring in the head. In the latter, the central light is not unfrequently slightly higher and wider than the lateral ones (fig. 11), this being the only idea traceable to the early English triplet (fig. 2). It follows that windows of four and eight lights are formed by a repetition of the design of two lights. Thus, the great east window of Lincoln Cathedral (fig. 15), the most splendid of all pure geometrical examples, exhibits in the head a large circle (filled with seven smaller foliated circles)

Fig. 12.

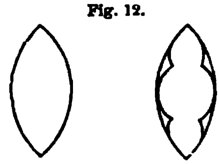


Fig. 13.

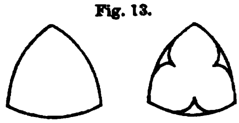


Fig. 14.

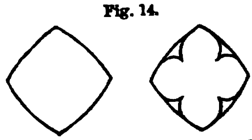
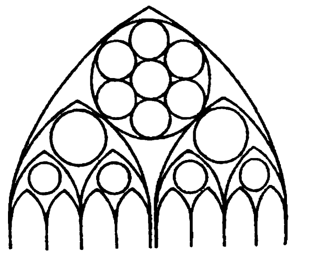
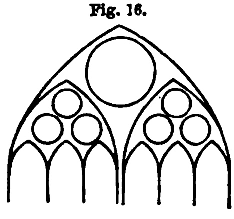


Fig. 15.



carried by two arches, which enclose, severally, a large foliated circle carried by two arches, which also contain a circle carried by two lights, thus forming the whole eight. Windows of six lights (fig. 16) have a circle in the head carried by two arches, enclosing fenestellæ or subordinate windows, each of which is filled up with the design of a three-light window. Windows with seven lights have similar fenestellæ, but a complementary light is introduced between them, on which, as well as on the fenestellæ, the circle is supported. Five-light windows have likewise a complementary light which carries the circle in the head, flanked by fenestellæ with the design of a two-light window.

Fig. 16.



The same relative design in the succeeding stage exhibits the triangle, the vesica, and in a few instances in England the square, conjointly with, or in place of, the circles of the earlier period (fig. 17). Foil figures also appear

Fig. 17.

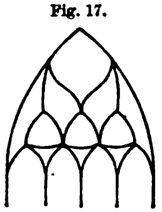
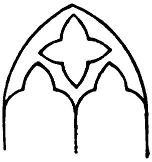


Fig. 18.



(fig. 18), i. e. the foliations of a circle or triangle are now seen as independent figures, the containing figure being knocked out. Both the arches and the tracery bars frequently assume this form, every succeeding developement of figure tracery being followed by a similar developement in foil tracery.

Thus far the great characteristics in the developement of tracery are: (1) the separate existence of the parts as opposed to the fusion apparent in the *Flamboyant* (fig. 19) and *Perpendicular* (fig. 20), and (2), as a consequence of this principle, the subordination of mouldings. In the continuous styles, so far as their nature is suffered to have fair play, the whole working

Fig. 19.

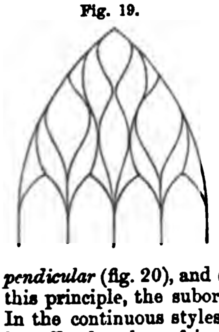
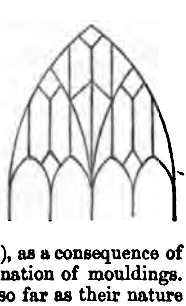


Fig. 20.



of a window is on one plane, whereas in the geometrical windows the primary mouldings are confined generally to the two principal arches and the circle which they carry, and where the number of lights is uneven, to the small subsidiary arch below the circle forming the head of the central light. The skeleton of the design being thus formed, the secondary mouldings develope the principal forms of the tracery, and define the outline of the foliated figures. In fact, geometrical tracery was never intended to do more than support itself; and the proof of this assertion is furnished by the fact that the tracery and mullions were almost invariably set after the window arch was completed, being designed only to fill the vacant space and carry simply their own weight; whereas, in modern work of the same style, it is not uncommon to see considerable portions of the mouldings of the window arch worked together with those of the tracery on the same stone.

The later styles are more complicated, and exhibit not merely a pyramidal piling but a fusion of parts, in which, instead of independent inserted figures, the tracery is formed of spaces bounded by lines continued from the mullions, not in an actually vertical direction, but ramifying towards different points (fig. 19). What the circle is to the geometrical, the vesica is to the flowing or flamboyant style. In practice, the combinations furnished in this style, often in conjunction with the preceding, are indefinitely various. Sometimes the skeleton is flowing, the filling up being geometrical, and vice versâ; and sometimes the head is geometrical, while the fenestellæ are flowing. The principle of flowing windows is the same as that of the continuous or perpendicular, however unlike they may at first sight appear. In both, the mullions are continued to the head, in the one in straight, and in the other in wavy lines. The notion of separate figures is gone: there is no subordination of mouldings, nor do we anywhere find vacant spaces. The later specimens of the continuous style in this country betray a tendency to revert to earlier forms, designs being in some instances produced in which the perpendicular line is entirely absent.

The developement of tracery brought about the foliation or *cusping* of the several figures contained in the design; and although the circle, vesica, triangle, and square are found uncusped (figs. 12, 13, 14), even in some elaborate windows (as at Grantham, in Lincolnshire), such instances are comparatively rare. These cusps seem to have originated in the idea of a figure filled with imperfect figures, part of the latter being knocked away: thus, at Oundle, four imperfect circles join a perfect circle, in the centre (fig. 21); if this perfect circle be removed, a cusped quatrefoil remains (fig. 22).

The cusp in foliations so obtained, assumed the form (fig. 22) known as the *truncated soffit cusp* (Paley's *Gothic Architecture*, p. 161); but the later and more common form is that

of the pointed cusp, which is exclusively used in the later styles.

The window tracery of the Continent follows essentially the same laws, although the transi-

Fig. 21.

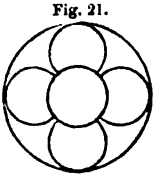


Fig. 22.

tion from the employment of mere round-headed apertures to fully developed tracery is more rapid, and marked by fewer intermediate steps than in this country. The English lancet style finds scarcely any parallel in Europe, and in Germany the spherical triangle and spherical square become more favourite figures than the circle or even the vesica. In England the flowing soon gave way before the perpendicular style; in France, as in Germany, the former took the strongest hold, and was developed (most luxuriantly in France) into the lavish gorgeousness of the flamboyant (or flame-like) style.

In Italy, as there was at no time a genuine Gothic style, so the forms exhibited in the tracery of windows are mere imitations of the forms employed by the northern architects, by whom many of the finest Italian buildings were designed. In the *Renaissance* styles no attempt has been made to develope any new forms of tracery, and for the most part they have not employed this feature at all, the windows being again reduced to mere apertures, which not unfrequently disfigure the whole design. (Freeman *On the Origin and Developement of Window Tracery in England*; Sharpe's *Rise and Progress of Decorated Window Tracery in England*.)

Trachea (Gr. τραχεῖα, from τραχύς, *rough*). The windpipe. A cartilaginous and membranous tube through which the air passes into and out of the lungs. Its upper extremity is called the *larynx*, and consists of five cartilages. The uppermost forms a kind of valve at the mouth of the larynx or glottis, and is called the *epiglottis*: it closes the passage in the act of swallowing. The sides of the larynx are formed by the *arytenoid* cartilages, and the anterior part of the *thyroid* and *cricoid* or annular cartilages; these may be felt under the skin in the front of the neck. These cartilages are united by elastic ligaments, and are acted upon by appropriate muscles, so as to modify the dimensions and form of the aperture in the act of speaking: they are moistened by a mucous secretion. The canal from the larynx downwards is called *trachea*, till it divides into two *bronchiæ* opposite the fourth or fifth dorsal vertebra. They are kept open for the free passage of the air by their elastic cartilaginous texture, which consists of rings with intervening membrane and muscular fibres.

Tracheæ. In Botany, the spiral vessels of plants, which received that name because they were regarded as the respiratory tubes of plants. *Trachenchyma* is a tissue composed of tracheæ.

Trachearies. The name of an order of the class *Arachnida*, including those which breathe by means of tracheæ.

Trachelidans (Gr. τράχηλος, *a neck*). The name of a family of Coleopterous insects, comprising those which have the head supported on a kind of pedicle or neck.

Trachelipods (Gr. τράχηλος, and πούς, *a foot*). The name given by Lamarck to an order of Molluscs, comprehending all those which have a free and flattened foot attached to the under side of the part of the body which he considers as analogous to a neck. The order corresponds nearly with the Pectinibranchiate Gastropods of Cuvier.

Tracheocele (Gr. τραχεῖα, and κήλη, *a tumour*). A tumour upon the trachea; an enlargement of the thyroid gland. [Bronchocele.]

Tracheotomy (Gr. τραχεῖα, and τέμνω, *I cut*). The operation of making an opening into the trachea in cases of threatened suffocation.

Trachinus (Gr. τραχύς, *rough*). A genus of spiny-finned fishes, characterised by their compressed body and approximated eyes; two dorsal fins; the first short, and with spinous rays; the second long, and with flexible rays. The anal fin is very long; the operculum is armed with a long spine directed backwards. By the wounds which the species of *Trachinus*, usually called *weevers*, inflict with their opercular spine, they have become formidable to fishermen of all nations; and it is said that the French have a police regulation, by which the fishermen are directed to cut off the spines before they expose the fish for sale.

Trachitis. Inflammation of the trachea.

Trachyte (Gr. τραχύς). A variety of lava which is often porphyritic, and when containing hornblende and augite passes into the varieties of trap called *basalt*, *greenstone*, *dolerite*, &c.

Tract, Treatise (from Lat. tractatus). It would be difficult to assign any reason for the difference in signification between two words identical in origin and etymological meaning; but the first is now commonly used to describe short compositions, in which some particular subject is *treated* generally in the form of a pamphlet; the latter, more extensive works.

Tractarians. In Modern Church History, a party name given to those members of the church of England, chiefly from the university of Oxford, who headed the theological movement which definitely took shape in 1833. (Newman, *Apologia pro Vitâ suâ*, p. 100, and passim.) The celebrated *Tracts for the Times*, from which the appellation is derived, began to appear in that year: the knot of writers who produced them being chiefly actuated, in the first instance, by hostility to the Whig

government in its measures, commenced or apprehended, for the reduction of the Church establishment in England and Ireland. But their purpose soon diverged to the wider scope of re-establishing High Church doctrine and practice on the level of the school of Laud and Andrewes. The *Tracts* continued to appear occasionally, until some of them, culminating in Mr. Newman's celebrated *Tract No. XC.*, indicated plainly a tendency to coalesce with Rome. This tract appeared in 1841, and excited a storm of opposition, under which the *Tracts* ceased to appear, and one of the two recognised leaders of the party (Mr. Newman) in no long time submitted himself to the church of Rome.

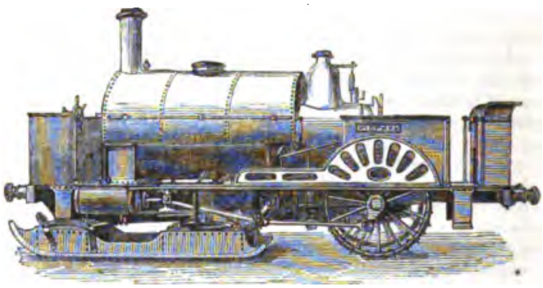
Traction Engine. A species of locomotive engine for drawing heavy loads upon common roads. Before the general introduction of the railway system, steam carriages, capable of maintaining a speed of twelve or fourteen miles an hour, were proposed in substitution of the common horse coaches; and several steam carriages of this character were constructed and tried. But the rapid extension of the railways extinguished this traffic, and all idea of achieving high rates of speed by locomotives on the common road has been abandoned, in countries at least in which railways exist. But a species of steam waggon, called a *traction engine*, has latterly been introduced for drawing heavy loads upon common roads at a low rate of speed, and such steam waggons are also used for steam cultivation and for all the purposes of threshing, sawing, and pumping, to which the common agricultural engine is applied. In drawing heavy weights, traction engines have this special feature of advantage over horses, that whereas it is difficult to get the horses to start or stop, or pull together, the engine power can be managed with the greatest facility. Traction engines are consequently much used for drawing boilers, guns, and other heavy weights.

One of the earliest forms of traction engine is that known as Boydell's, to the wheels of which are fitted chains of boards forming a species of endless railway, which the engine lays down and lifts up as it proceeds, being thus enabled to travel over soft ground. Engines of this kind have been employed to traverse a field drawing rows of ploughs behind them, and a whole furrow has thus been ploughed up at once. Another form of traction engine is that known as Bray's, in which the wheels of the engine, which are made very wide, rest on the ground; and to prevent the driving wheels from slipping when rotated, sliding plates or grippers are projected through the tire of the wheels by central eccentrics, which projections gear with the ground and compel the waggon to advance. Most of the makers of agricultural engines also construct traction engines, which are so made that they can perform the general work of the farm, and at the same time draw the agricultural produce along the roads. These traction engines are for the most part constructed with a single cylinder, lying on top of the boiler; and gearing, and also very frequently a pitched chain, is interposed between the engine and the driving wheel, so as to enable the engine to develope its power by moving fast while the driving wheel rotates at a moderate speed. The traction engines of Aveling and Porter, Clayton and Shuttleworth, Garret and Son, Robey and Co., and most other makers, conform to this general description. But Robey and Co. have also a highway locomotive with large wheels, which is intended to maintain on the common road higher speeds than their traction engine is capable of. In Chaplin and Co.'s traction engine, as constructed in 1866, the boiler is vertical and is fitted with Field's tubes, which are blind tubes, hanging from the top of a high fire-box, and each fitted with a smaller internal tube through which the water descends, while the steam and water ascend round the annulus, an efficient circulation being thus maintained. The carriage is fitted with side frames, as in a locomotive, to which the cylinders, seven inches in diameter and fourteen inches stroke, are bolted. The crank shaft carries three malleable cast-iron pinions, each of which can at pleasure be placed in gear with a corresponding spur-wheel, also of malleable cast iron, fixed upon a countershaft; and each end of the countershaft carries a pinion, which gears into wheels with internal teeth attached to the driving wheels. By suitable clutches, either driving wheel may be driven or thrown out of gear; and by shifting the suitable pinion on the countershaft, so as to gear with its corresponding wheel while the others are placed out of gear, the carriage may be propelled at the rate of two, four, or eight miles an hour. The exhaust steam, instead of being discharged in puffs up the chimney, is discharged into a tank or reservoir placed between the frames, whence it escapes up the chimney in a continuous stream. The driving wheels are six feet in diameter and fifteen inches wide in the tire, and projecting grippers or spades may be projected through the rim to gear with the ground, as in Bray's plan. The carriage is fitted with springs as in locomotives.

There are many countries in which traction engines would be of great value, from the existence of good common roads, the scarcity of railways, and the trying nature of the climate to animals employed for draught. In 1866 measures were taken to establish such engines on the road leading from Beyrout to Damascus, in Syria, a distance of sixty-eight miles. These engines have been constructed by Messrs. Dübs, of Glasgow, from the designs of Mr. Clarke; and as they have to surmount the Lebanon and Anti-Lebanon ranges, they are intended to draw ten tons of goods over inclines rising one in twelve, at the rate of from three to five miles an hour. The general arrangement of the engine resembles that of a locomotive. The driving wheels are furnished with Bray's teeth; but they are made hollow to enable the actuating rod to be attached to the

bottom of the tooth, instead of to its inner end, the tilting action before experienced with that apparatus being thus prevented. The engine carries 500 gallons of water and 15 cwt. of coal, and when tested, in July 1866, was found to perform all that was expected of it.

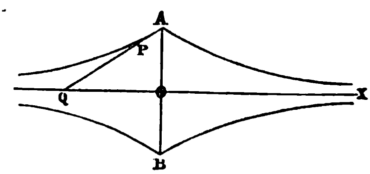
An interesting application of the traction engine for running upon ice, is represented in the annexed figure. This engine was constructed by Messrs. Neilson of Glasgow, and is reported to have been successfully employed in conveying goods and passengers on the Neva between St. Petersburg and Cronstadt during the winter months. The front part of the engine rests on a sledge, which is capable of being moved round a centre by a pinion gearing into a segment, and worked by the steering wheel shown at the front, which gives



motion to an endless screw gearing with a suitable wheel, which turns the spindle of the pinion round with great force; and by swivelling the sledge—which, however, would be better done by a small engine—the machine is steered. The after part of the engine rests upon two driving wheels 5 feet in diameter, the peripheries of which are studded with steel spikes to grip the ice. The cylinders are of 10 inches diameter and 22 inches stroke. The weight of the engine is 12 tons, and it realises a speed of 18 miles an hour. It will be proper in such an engine to apply a shelving edge on each side of the sledge, so that its swivelling may not be prevented by sinking somewhat into the ice or beaten snow; and to the same end the swivelling gear should be powerful, and under easy and rapid control under the worst circumstances likely to occur. In Russia and in Sweden extensive lakes and other tracts of water, being frozen in winter, are available for the application of such an apparatus. But in some of the lakes there are warm springs which create holes in the ice; and the desideratum to be aimed at is to render available the little vessels which ply in summer for plying also in winter by mounting them on a sledge, as was proposed by Mr. Bourne to be done for some lakes in Sweden in 1847.

Tractors, Metallic. Small bars of metal which were supposed to possess certain magnetic powers, and to cure painful affections and tumours by being drawn over the part. They bore the name of their inventor, Perkins, and were much used about thirty years ago. A number of wonderful cures, however, having been attested, which were performed by means of spurious wooden tractors, the imaginary virtues of the magnetic or metallic fell into disrepute, and were soon forgotten.

Tractrix (Lat. traho, *I draw*). A transcendental curve possessing the pro erty that the portion P Q intercepted upon every tangent, between the corresponding point of contact P, and a given fixed line O X, has a constant length O A = *h*. It belongs to the family of equitangential curves, and evidently consists of four



symmetrical branches having the given line as asymptote and two cusps at A and B. Its equation is readily found to be

$$x = h \log\left(\frac{h+\sqrt{h^2-y^2}}{y}\right) - \sqrt{h^2-y^2}$$

Its evolute is the catenary. [CATENARY.]

The name *tractrix* or *tractory* was given to the curve by Huygens, who conceived it to be generated mechanically by a small weight P attached to a string P Q, the other extremity of which is drawn along the fixed line X Q. (D'Alembert, *Encyc. Méthodique*; Peacock's *Examples*; Salmon, *Higher Plane Curves*.)

Trade (Ital. tratta). The exchange of commodities between town and country, producer, dealer, and consumer, nation and nation. Trade is either home or internal, or foreign.

The origin of trade is contemporaneous with the earliest civilisation. Mutual needs bring about mutual exchanges. In time, this humanising communication extends to other countries, and would be general if the evil passions and selfish interests of men did not interfere to check or hinder the developement of these reciprocal benefits. Either from what is called public policy, and which generally means the cultivation of jealousies between states supposed

to be rivals in ambition, the intercourse which the instincts of men suggest, is impaired; or in deference to the influence of certain classes who fear rivals in production, and who are able to control the commercial interests of a nation, protective or prohibitive arrangements are made, and the course of trade is diverted from its natural course to unprofitable channels. [FREE TRADE; PROTECTION.]

The extension of trade, in the absence of these unnatural restrictions, is limited only by the width of the market; and the market becomes wider, in so far as the means of transit or carriage are rendered cheaper and more regular. The cost of carriage is diminished partly by the developement of mechanical arts, partly by the practical study of physical geography. Thus the art of shipbuilding, and of engineering by land, though we cannot assert that they have reached perfection, are improving yearly; and as the physical peculiarities of the sea, the currents, the prevailing winds, and the like, are better known, the cost of sea passages is diminished by the diminution of the time needed to perform them. So, again, the power of establishing such communications as shall insure a rapid and exact knowledge of the markets, is of great moment in securing that uniformity of prices, and diminution in the risks of trade, which constitute to the consumer no small part of the cost of such commodities as he needs. Speculation, i. e. the disposition to purchase in the hope of a rise, though of great importance as an economical process in regulating the price of the *first necessaries* of life, is a great evil in such branches of trade as deal with the *conveniences* of life, because in so far as it operates on prices, it tends to exalt them by increasing the risks of the dealer and the supply to the consumer.

The French economists, of whom Turgot and Du Quesnay were the most ancient, entertained the notion, that of all kinds of trade, agriculture was the most advantageous, manufacture being placed next, and commerce last. This view, due in no small degree to reactionary feeling against the mischievous policy of the French government, was embraced by Adam Smith (book ii.), and forms one of the chief errors in his great work. It is plain that the advantage or disadvantage of any trade, if exchange be free, is determined by present, and not by abstract considerations.

The growth of trade in this country is due, partly to the early adoption of the principles of free trade, and the abolition of restrictions; partly, we may perhaps say, to the energies of the people, and their adventurous temper; not a little to the fact, that this country, being insular, and possessing a singularly large number of accessible harbours, is also under these conditions the commercial centre of the largest and most fully occupied part of the earth's surface. [COMMERCE; EXCHANGE; GEOGRAPHY, POLITICAL; PRODUCTION; ROUTE, COMMERCIAL.]

Trade, Board of. A branch of the Privy Council, properly styled Committee of the Privy Council for Trade and Plantations. This body originated under Charles II., and its history is satirically described by Burke in his speech on economical reform. It was, he says, 'a showy and specious imposition,' reproduced 'as a job' on an occasion of distressed trade in 1696, 'to quiet the minds of the people;' and 'perhaps,' he adds, 'it is the only instance of a public body which has never degenerated.' Once more reconstituted in 1786, it continued as a body of rather anomalous functions, but chiefly useful in practice to assist other departments of state by answers to references on questions connected with the trade of the empire. Of late years, however, various statutes have conferred on it important functions of administration. It has extensive powers for the control of merchant shipping and seamen; a supervision over railways, transferred to this board in 1852 (14 & 15 Vict. c. 64); it registers joint-stock companies since 1858 (19 & 20 Vict. c. 47; 25 & 26 Vict. c. 89), superintends the coal trade of the port of London, &c.

Trade Mark. One of the greatest risks which the trade of any country can run, is that of dishonesty or fraud on the part of producers or dealers. Over and over again, successful branches of commerce have been ruined by the fraud of persons who have pretended to supply goods of equal merit with those to which purchasers have been habituated, but have supplied inferior or useless articles. A singular illustration of this fact is given in the late report of Birmingham industries, p. 273: 'Immense quantities of a species of money, known as Manillas, were at one time produced in Birmingham by casting. It was exported to the Spanish settlements on the Old and New Calabar and the Bonny rivers in Africa.. In an evil hour, however, a sharp trader, not a little unscrupulous. animated by a desire to become speedily rich, conceived the brilliant idea of producing these objects in cast iron, and coppering them over by the electro-deposit process. On their arrival at their destination the deception was at once detected. This gave the quietus to the manufacture of "Manilla" money in Birmingham till very recently.' The author goes on to state the precautions which the negroes take to test the small quantity which they now receive. Over and over again, it has been found impossible to establish trades, because no valid security can be given that agents and intermediate dealers will be honest. The correction to these vices, which always react on those who practise them, may be hoped for partly in the spread of moral principle and an enlightened interpretation of what constitutes real self-interest, partly in the effectiveness of private and public police. The latter of these methods of repression is not necessarily operative, for it is not always easy to be sure of the integrity and activity of those who are appointed to watch over the administration of law; the former is to some extent satisfied by the use of *trade marks*, and the interest which honest producers

have in securing themselves against forgery of the symbols adopted by them in order to distinguish their wares from those manufactured by rival houses.

These symbols are known as trade marks, and the custom of using some such marks has become almost universal among those traders who believe that such an advertisement is at once a means for diffusing the knowledge of their goods, and of protecting themselves from fraudulent imitations.

The earliest of these marks appear to have been those which were used in the manufacture of paper; and of paper water-marks, the earliest appears to be on a document bearing the date 1351, i. e. shortly after the invention of paper from linen rags. Trade marks have also been used for a long time on cutlery; and in some cases, as in the ancient statutes relating to wool, the use of a trade mark has been recognised by Act of Parliament.

Trade marks have, however, been very commonly forged or counterfeited, and the Court of Chancery has in numerous cases been called on to interfere by injunction for the purpose of restraining this practice. By a recent statute (25 & 26 Vict. c. 88), frauds of this nature have been made punishable by fine and imprisonment.

Trade Winds. Winds which in the torrid zone, and often a little beyond it, blow generally from the same quarter, varying, according to circumstances, from N.E. to S.E.

The cause of this wind is to be ascribed principally to the high comparative temperature of the torrid zone, combined with the rotation of the earth from W. to E. As the heated air at the surface ascends into the higher regions of the atmosphere, its place is supplied by the colder air rushing from the poles. This colder air, also becoming rarefied, ascends in its turn, and is carried in the upper regions towards the poles to supply the stream of the under current; and these under polar currents moving in progress towards the equator from the zones where the earth's motion is slower to others where it is more rapid, acquire an apparent relative motion in a westerly direction. As the currents from the two hemispheres meet near the equator, their meridional motions are there destroyed, and they therefore advance together with the remaining motion from the eastward round the globe. The regularity of the trade winds is disturbed in some places by local causes, and chiefly by the superior rarefaction of the air over land heated by the sun's rays. They extend farther to the northward or southward according as the sun's declination is north or south; and in some places they become periodical, blowing one half of the year in one direction, and the other half in the opposite one. [MONSOON.] In the great Pacific ocean, however, the trade wind blows with a uniform and gentle breeze all the year round. The name of *trade winds* was given to them from their important influence in commerce, expressing, as they do, the '*wind blowing* trade.'

Trades' Union. An arrangement or combination entered into by the workmen of particular trades, or manufactures, in order to regulate the prices of labour, the hours during which labour is employed, and not unfrequently the number of workmen engaged by an employer, the number of apprentices bound to the employer or his foremen, and the number of journeymen. The purpose of a trades' union is, therefore, the settlement of the proportion which wages should bear to profits. The effectiveness of a trades' union depends on: (1) the esprit de corps of the workmen themselves; (2) moral restraint; and (3) unfortunately, when men's passions are heated, coercion exercised on those who are unwilling to join the trades' union or are indifferent to its real or supposed advantages; and (4) failing the consent of the employer or general body of employers to the demands made by workmen, the last remedy of a *strike*. Of late years, the association of workmen for these purposes has occupied a considerable amount of public attention, and even alarm, although no one has ventured to suggest that such combinations ought to be repressed by authority, while many have asserted and argued that a trades' union, with all its machinery (short, of course, of coercion), is a natural expedient, and a legitimate defence against wrongs which it is presumed may be inflicted on labour by the power of capital.

Before 1825, combinations between workmen for the purpose of raising wages were treated as conspiracies, and were punishable by a variety of statutes. The history of these statutes is important and well defined, and if it were granted that a combination is economically and socially indefensible, it would still have at least an appearance of equity, because it was a natural reaction against wholly inexcusable acts of the legislature.

The inevitable consequences of the great plague of 1348 (for the labour statutes of English law date from the second year after that great event) were a rise in the price of labour, sometimes to double its previous rate, almost invariably to seventy per cent. The reader may see the evidence, extracted entirely from contemporaneous records of farm and other accounts, in the first two volumes of Prof. Rogers' *History of Agriculture and Prices in England*. In order to check this rise, a statute was passed in 1350, which attempted to prevent any change, by fixing the rate of wages and by levying penalties on those who paid or received more than the old rates. It is almost unnecessary to say that the legislation was inoperative, and that high prices of labour, despite the law, were demanded and paid. But the statutes of labourers were enacted in one form and another over and over again, and with fresh provisos, or with new machinery, intended to secure the objects of the law. Meanwhile, as the price of labour rose and fell according to those natural causes which exalt or lower wages, the law, on some occasions, was

apparently effectual, while a strong impression was left on the minds of labourers that the various statutes really checked or controlled the rate of wages. If, therefore, we are disposed to criticise the action of servants or labourers in combining together for the purpose of raising wages, we should remember that for 475 years the whole force of the legislature, stimulated by the perpetual complaints of employers, was directed towards the depression of wages by artificial means. The means employed were wholly or nearly nugatory, but the intention was reasonably looked on as the same as the deed, and it was difficult to believe that all this force was wasted, and all these statutes futile.

In truth, throughout the whole economical history of England, these laws have, it seems, failed of producing the slightest real effect. They may, perhaps, have occasionally enabled an employer to break his contract, they may have been vexatious and alarming, but they never affected the average rate. Wages were very high, as estimated by the price of food, in the two hundred years between 1350–1550, and fell considerably between 1550–1700; rose again between 1700–1760; fell again till after the peace of 1815, and have been on the whole steadily rising since. These changes, however, have not been, as we might expect, brought about by any law, ordinance, statute, or proclamation, but simply and solely by those economical causes which, under the formula of supply and demand, fix the prices of labour as they do the prices of anything else.

When, however, the statutes enacted in the interest of employers were abolished, the laws checking combinations being at the same time relaxed, it was natural that such combinations should be entered into. But it may be doubted whether any such arrangements would have been made, or, if they had been made, would have spread, or have obtained the least share of public sympathy or approval, or would have warranted the fundamental assertion of a trades' union that it is necessary to protect the workmen against the tyranny of capital, had it not been for these 475 years of unjust, vexatious, and selfish enactments.

The operation of a trades' union, and its purpose (viz. the regulation of wages by other arrangements than the natural action of supply and demand), may be considered either in relation to the workmen themselves, in relation to the employer, in relation to labour generally, or in relation to the public, i.e. the purchaser of those commodities or utilities which are affected by a union. But to make all these efforts clear, it is necessary to say a word about the fund from which wages are paid, i.e. floating capital, or the labour fund.

The source of wages is capital. Without it there could be no employment. Capital is accumulated with a view to profit. If sufficient profit is not attained, capital ceases to be collected, and in such a case, labour is no longer employed. Whatever, then, be the demands of labour, they cannot supersede profit. Hence, if by any machinery certain classes of workmen contrive to appropriate a larger share of wages than other workmen, or more than they have hitherto received themselves, they must either obtain a portion of that which would otherwise go to other labourers, or they must raise prices. They must either mulct the labourer or the consumer. They will partially lay a loss on both.

It may be doubted, however, whether any such machinery will really raise wages. Few strikes have been successful, and those which have been most prolonged have generally been followed by a resumption of work at old charges; and though it is asserted that the dread of a strike has induced masters to advance the rate, it may be questioned whether the demand for labour would not have effected this advance by itself. No rates of wages have risen like those of domestic servants, especially those of females. But combination, or any mutual arrangement with a view to raising wages among domestic servants, has not only never existed, but is manifestly out of the question. Nor does it follow that persons will readily find out the futility of plans in which they place an undeserved confidence. It has been found over and over again that protection is no real aid to industry, long before protected industry has discerned the delusion for itself.

But though the machinery of a trades' union may not raise wages, it may affect labour itself. The organisation which attempts to secure labour its rights must extend its aid to all the labourers who are leagued in the union. Hence the common reproach against trades' unions, that it depresses the best workmen to the level of the worst, and thus renders labour ineffective. The same result would seem to follow from such regulations as those which prescribe, for instance, the way in which a bricklayer should work, and the attendance which he should have. A rule of this kind, and other similar rules, may not have the effect of raising wages, but may raise prices by raising the cost of production. That these rules have this effect may, it appears, be proved incontestably by testing the rate of wages at different times, and comparing the cost of, say a building in an ancient bill, with a modern estimate for the same work.

Suppose, then, that labour is rendered less effectual, the labourers who enter into these arrangements may injure other labourers in two ways without benefiting themselves. They may appropriate, by an undue number of hands, a larger share of the common fund than would fall to their lot if the arrangements were wholly free, and they may make the article which they produce, and which may be used, and commonly is used, by those who are unable to combine, dearer, and therefore more inaccessible. To illustrate this in a simple way, suppose a cottage costs under the present system 150*l.*, and that 50*l.* of this sum is added by the fact that labour is less effectual than it would be in the

absence of trade regulations. Fifty pounds' worth of labour is appropriated by the building trades, while it might have been spared for other labour, and the cottager has to pay interest in the shape of rent on 150*l.* when he might have had to pay it on 100*l.* only. If some part of the wages are appropriated in this way it must be to the detriment of other labour, for a general rise in labour is as absurd as a general glut, or a general rise in values.

It is said that capital is tyrannical. Now there is no economical truth more certain than that profits tend to an equality. But by tyranny must be meant an attempt to secure greater profits by grinding down workmen. If greater profits were temporarily attained, it is impossible to keep the secret, and competition will soon reduce them. If by tyranny, however, is meant a constant watchfulness, and perhaps occasional harshness, in attempts on the part of the capitalist to save himself from the risks of a strike, it is hardly just to call that a tyranny which is retaliatory or perhaps a mere act of self-defence, and certainly the capitalist will not run these risks unless he is tolerably certain to save himself, either by prompt action with his labourers, or by increased charges to the public.

We have said that a general rise in wages is out of the question, and by implication, that a universal trades' union would defeat itself. As a rule, then, a union is most powerful among such mechanics as are occupied in supplying the second necessaries of life, and especially in the building trades. But they who join the union cannot avoid using that which they produce; and provided there be no real rise effected in the rate of wages by the union, while the price of the commodity is enhanced by the regulation, it seems that the labourer can only gain a loss by the arrangement which he makes. Now a rise in the price of the second necessaries of life always falls heavily on persons with narrow incomes. If two persons have respectively 100*l.* and 1,000*l.* a year, the cost of house rent will represent a higher per-centage in the former than it does in the latter case. It is clear, then, that the effect of a trades' union on general labour, and its effect on the customer or consumer, is by no means beneficial.

The outrages and persecutions which generally disfigure trades' unions and strikes are not a necessary feature in this organisation, but a natural sequence. If workmen believe that a trades' union benefits them, they necessarily look on the man who stands aloof as disaffected to the interests of their order, and if he takes employment when men are on strike, he is regarded as a traitor to the working man, and a hindrance to the purposes for which the strike was organised and directed. When the etiquette of professional practice is so strong and its social police so stringent, we can hardly wonder that working men should adopt their process of energetic excommunication against those who discredit or weaken their cause.

To those who are but slightly acquainted with the principles of political economy, it will be clear that the origin of these combinations is to be found in an excess of labour over capital (for in times when labour is in demand we hear nothing of this organisation), and that the state of things becomes chronic by reason of the improvidence of workmen. If the means of any artisan enabled him to say that he would find elsewhere a market for his labour (and in the great majority of cases such a market does exist) when the home demand fell short, he could readily attain the maximum for his wages which the market will bear. There cannot be, in the nature of things, any reason why labour should not assert a right which capital (the employment of which is only another kind of labour) cannot assume, i.e. the right of being employed in a particular locality, or at least on fixed terms.

But, in effect, the remedy is in the hands of working men to a far larger extent than they imagine. The true solution of these apparent relations between labour and capital, is to unite them in the same person, i.e. to adopt the practice of co-operation. A union of fifty or a hundred workmen, with an aggregate of all their capitals in a building company, would do more to determine for them the true relations of the above-named economical elements, than all the unions in existence. There can be no more reason why a workman should not be possessed of capital for his own craft, than there is that a trader or a professional man should not have it. Accordingly, it appears that trades' unions in many quarters are now looked on by working men with disfavour, and with doubts as to their real efficacy; and that emigration and co-operation, the one abroad and the other at home, are becoming extensively popular.

Meanwhile, the losses which labour and capital have suffered in these battles of endurance have led both parties to attempt conciliation by appointing arbiters in cases of dispute. To the credit of the artisans it should be said that they have been far more willing to submit to this arrangement than the capitalists, who resisted this rational measure during the time of the nine hours' movement of 1862. Such a scheme has been long known in France, under the name of *conseils des prudhommes*, and it may be hoped that similar means will be adopted in this country. [COMBINATION.]

Tradition (Lat. traditio, *a handing down*). In History, this term is generally applied to narratives or statements relating to alleged events, which have not been preserved in documents contemporary with the period of which they profess to speak. Like all written historical narratives, the subject-matter of tradition must be estimated by the measure of credibility due to the original witnesses, and by the degree of fidelity with which their testimony has been preserved. It is scarcely necessary to remark, that when statements, handed down by oral tradition, have been reduced to writing at a time long subsequent to that in which the events are stated to have

occurred, the character of the narrative is in no respect altered, and the statements remain strictly the result of oral tradition and not the result of written contemporary history.

Oral tradition is thus separated from all contemporary historical documents. It is unconnected with the evidence of inscriptions on public monuments, the registers of magistrates, or written genealogies, or a written chronology. The tests for measuring the value of these various sources of information are given in the article Historical Credibility; and as these tests all involve the paramount need of known contemporary and trustworthy witnesses, it is obvious that statements coming to us from alleged witnesses whose words were not reduced to writing at or near the time to which they belonged, must be subjected to an unsparingly rigorous scrutiny by all who wish to arrive, not at possible pictures of events which may have taken place, but at the actual truth of facts. In other words, oral tradition must, as such, be regarded with grave suspicion.

It must, however, be admitted that the oral traditions of one nation may be far more deserving of credit than those of another. In states of society which are permanently fixed by clanship, or by the spirit of feudalism, and in which consequently the bulk of the population is tied to the soil, local traditions may be maintained with a fidelity for which it is vain to look in conditions of society under which popular sentiment is continually changing. By the nature of the case, all oral traditions are liable to modification by the colouring thrown over them by the narrator, and this colouring must vary with every deviation from the sentiment or conviction of the original witness. In this respect, the sons or grandsons of those among whom a tradition is established stand on a footing differing indefinitely from that of their predecessors. On those with whom they are brought into personal contact, the motives and words of men are more deeply impressed than the results which may be produced by them; but a later generation is, in constantly increasing measure, tempted to forget their words and motives, while it retains a fair recollection of the objects which they attained or sought to attain. The details of each narrative become gradually weaker and more faint, until not unfrequently there remains only some barren statement which has lost all life and meaning. Thus the force of oral tradition is weakened with each successive generation. In countries where there is no written history, the sons know a good deal about the incidents in the lifetime of their fathers, a little about the fortunes of their grandfathers, and next to nothing of the events of a more remote age. In an age of written history, on the other hand, the time which a little precedes our own birth is generally that with which we are least familiar. Its records have not yet been thrown into their permanent historical form, while the chief actors are passing away from the scene, and the mass of original documents out of which the history of their acts is to be compiled are commonly far too bulky and too inaccessible to allow of much acquaintance with them, except within a comparatively small range. But the existence of these original documents is a guarantee against all those distorting influences (of personal motives, of jealousy, and admiration, of sympathy with a winning or a losing side) which are perpetually at work with ordinary oral tradition, and which tend to deprive us of all confidence in narratives orally handed down, except under certain conditions.

These conditions depend on the form in which the narratives are presented. Traditions, which may be regarded as the mere hearsay of a people, are constantly undergoing modification or corruption, from which they are comparatively free when thrown into a metrical form. We have no reason, apparently, for thinking that the Homeric poems contain any genuine history of early events in Greece and Asia Minor, but the compositions of the poems added indefinitely to the strength and permanence of the traditions embodied in them. Stories which, like the tale of Thersander and Attaginus (Herod. ix. 16), come to us through the medium of ordinary conversation are worth comparatively little; but the metrical form of poems popular amongst many friendly or antagonistic tribes insures, by the very strength of their mutual attachments or jealousies, a transmission which, with allowances made for trifling verbal alterations, may be regarded as thoroughly trustworthy. Apart from this guarantee, the preservation of the most beautiful legends becomes a matter of great uncertainty; and indeed it may be said that a change in religious sentiment, or the introduction of a new standard of criticism, will insure their destruction, except in so far as they are counteracted by that portion of the population which is free from such influences. If the tale of Troy had not been thrown into a metrical form, and if all his contemporaries without exception could have been brought to believe with Herodotus that Helen never went to Troy, but was detained at the court of the Egyptian king, it is certain that the whole legend of Achilleus and Agamemnon, of Paris and Hector, must have utterly perished, or have been preserved in a form wholly unlike that in which it is recorded in the *Iliad* and the *Odyssey*.

Again, in an age of unwritten history, national epics are regarded with a religious veneration, and the memory, not distracted with the manifold interests of a complicated civilisation, acquires a strength which to members of modern commonwealths seems incredible. Even in the time of Xenophon, Athenian citizens were able to repeat the whole *Iliad* and *Odyssey*, and the task must have been far easier when the whole story was

still received with a profound religious faith. This religious temper is especially manifested in the invocations and elaborate similes which precede the catalogue of ships in the second book of the *Iliad*, and which seem to prove beyond doubt that the poem was handed down at first by oral tradition only.

In some countries, an oral transmission, even more faithful, has been achieved even with compositions in prose; but this has been the work of an organised and despotic hierarchy. The whole Vedic literature was thus preserved by a class of men who submitted to a discipline against which an Homeric rhapsodist would probably have rebelled. Eight-and-forty years were spent on the gigantic task of learning the Veda by heart; and the resolution of these devoted students was sustained by anathemas which warned them that 'they who sell the Vedas, and even they who write them, shall go to hell,' while their teachers impressed on them the fact that 'that knowledge of the truth is worth less which has been acquired from the Veda if the Veda has not been rightly comprehended, or if it has been learnt from writing.' (Max Müller, *History of Sanskrit Literature*, p. 502, &c.) But the whole interest of this Vedic literature was religious; and there is perhaps no reason for supposing that the unwritten history of any given period, or of successive generations, has been preserved for the main part unchanged, unless when it has been intrusted to the vehicle of a metrical form.

Hence, in the transmission of a large body of early Hellenic legends we may have a confidence which cannot be extended to those of Rome. Even in the former case, our confidence must be limited only to the transmission of the tale from the time when it was versified, and we are as far as ever from being able to extract the historical truth which may be contained in them. But in the Roman legends we cannot even ascertain how far the myths were tampered with or altered during the whole period which passed before the popular traditions were reduced to writing. The great beauty of many of these traditions has tempted historians like Niebuhr and Lord Macaulay to assume the existence of Roman epic poems, which were lost before the events in Roman history were recorded by contemporary historians. For the truth of this assumption there is, in the judgment of Sir G. Cornewall Lewis (*Credibility of Early Roman History*, ch. vi. sect. 5), not a shred of evidence. To assert that the myths of Romulus and the Tarquins, of Lucretia and Virginia, were embodied in epic poems, because they are full of passages of striking power, eloquence, and tenderness, is, in his opinion, to assume that the matter of a composition, and not its form, decides whether it is or is not a poem, and involves the conclusion that all poetical prose is poetry; while, further, of the original poetical form of these Roman legends no trace remains, unless we adopt the desperate hypothesis of Niebuhr, that the lex horrendi carminis, recited in the myth of the Curiatii, is a genuine fragment of the lost poem. On this Sir G. C. Lewis remarks, that the term *carmen* here denotes merely a legal formula, which is about as poetical as the schedules of the income-tax Acts.

Our confidence in the faithful transmission of these legends, as legends, must depend on the degree in which they escaped modification in the hands of writers who regarded themselves as historians. They would be preserved with tolerable fidelity only by those classes which had least literary culture; and how far this was the case with the old Roman stories, we are now unable to ascertain. But in Greece also a vast body of oral tradition not thrown into verse floated down along with the metrical compositions of the Homeric cycle. The distortion of these legends was in some measure arrested by the comparatively early introduction of writing into the Hellenic states; but although these tales were written down at a time long preceding the rise of anything like a literature in Rome, the multiplicity of versions in almost every incident in the legends is evidence enough of the influences which are constantly at work to modify all myths not handed down in a metrical form.

The conclusion seems to be, that unless a legend is embodied in a poem we have no guarantee whatever for its faithful transmission even as a legend; that if it be thrown into metre, we have in this circumstance a ground for believing that the story has remained substantially unchanged from the time when it was thrown into that form; but that even in the latter case we have no reason for attributing to any part of it a genuine historical character, unless we can corroborate it by statements of contemporary witnesses derived from other sources. For the Homeric ages such sources are confessedly wanting, while the annals of Rome exhibit the defects of oral tradition down to the time of the Punic wars. [ROLAND; ROMULUS; SEMIRAMIS; SERVIUS TULLIUS; SESOSTRIS; SIGURDR.]

TRADITION. In Theology, this term is commonly employed to denote any doctrine or alleged fact, delivered or handed down, and received on the faith that the first to whom it was delivered received it from an authentic source. Hence, it is used, generally, to denote that body of doctrine and discipline supposed to have been put forth in the first Christian age, and not committed to writing, the word being thus used in a contrary sense from *Scripture*. Such traditions are said to be of two sorts—*tradition of doctrine* (such as that of the Trinity), which is commonly said to be directly affirmed by tradition and proved by Scripture; and *tradition of rites and ceremonies*, called by Hooker 'traditions ecclesiastical,' or 'ordinances made in the prime of the Christian religion, established with that authority which Christ has left to His church in

matters indifferent, and, on that consideration, requisite to be observed till like authority give just cause to alter them.' (*Eccl. Pol.* v. 65.)

To the historian, traditions of alleged facts in the history of the Christian church will be subjects for precisely the same critical scrutiny which he applies to all other traditions, and for them as for others he will demand the evidence of contemporary written documents. Traditions of doctrine, in so far as they are matters of inference from written statements, lie out of the province of history; but in so far as they turn on alleged facts, those facts must be submitted to the ordinary tests of historical credibility.

Ecclesiastical tradition thus involves generally two questions: 1. Whether the given tradition is derived by inference from written statements in acknowledged books; and 2. Whether it be a genuine tradition from the time to which it is professedly ascribed. The former is a question chiefly of logic; the latter is strictly historical. Roman Catholic and Protestant theologians treat the subject, respectively, as follows.

The former hold tradition to be of equal authority with Scripture; but then they also hold that the church, i.e. the pope, with or without a council, is the authoritative declarer of tradition. At the council of Trent, the difficulty of determining who is to say what is tradition and what is not, struck the minds of the divines who were contending to fix the doctrine of the Catholic church. 'All agreed,' says Paolo Sarpi, 'that Christian faith is contained partly in Scripture and partly in tradition. Yea, some said more: that tradition was the only foundation of the Catholic doctrine; for the Scripture itself is not believed but by tradition.' But Vicenzo Lanello, a Franciscan friar, thought 'that they ought first to treat of the church, which is a more principal foundation;' since 'Scripture itself is founded upon it,' according to Saint Augustine's saying, and 'that no use can be made of traditions, except by grounding them upon the same authority.' But his opinion had no followers. 'Some objected that the synagogues of the heretics would also arrogate the authority of a church;' others thought that the authority of the church was sufficiently declared already. (Book ii.)

Protestants, on the other hand, without laying it down as a doctrine that tradition is equal to Scripture, have, in general, assented to the proposition that an authentic tradition of doctrine is binding; but to the question, What is the authority competent to pronounce a tradition authentic? they have given many answers, from a reluctance apparently to admit to its full extent that right of private judgment on which they founded their dissent from Rome.

When the early Reformers, especially those of the Lutheran and Anglican schools, attacked a doctrine or practice of Rome, their first endeavour was generally to show that it was not scriptural; their second, that it was not *ancient*, i.e. did not rest on tradition. For this purpose, they opposed to the authority of the church, as it existed in their day, the authority of early fathers and councils, as expounding the belief of an earlier age. Thus they *recognised* the right of private judgment to try the authority of the existing church by comparing it with authorities of earlier times; they permitted each individual to apply for himself the historical test. But at the same time they denied, more or less directly, the right of private judgment to go further, and criticise the ancient authority itself; to examine, for instance, whether a doctrine acquiesced in, in the fourth century, might not have been altogether unknown to the first; whether corruption in the church may not have commenced at so very early a period as to invalidate greatly the testimony even of the oldest father; and, lastly, whether traditions, resting on high historical authority, are or are not reasonable and credible. And even to the present day, the high church school of Anglican divinity practically considers all these as points without the reach of private judgment.

It would be impossible to refer to particular works on this subject of controversy. The extreme Protestant view of tradition is nowhere so fully argued as by Chillingworth, passim. For a concise view, on high church principles, of the estimate of tradition by the English Reformers, see Palmer's *Church of Christ*, vol. i. pp. 493, 504.

Trafalgar. In Printing, the name of a large type used in printing hand-bills or posting-bills. [TYPE.]

Tragacanth (Gr. τραγάκανθα). A variety of gum, the produce of the *Astragalus verus*, *creticus*, *gummifer*, and one or two other species. It is imported in small twisted or flattened pieces, white or yellowish in colour, and translucent or nearly opaque. When put into water they swell up and gradually form a gelatinous or pasty mass; not dissolving into a clear solution, as is the case with gum arabic. An analogous kind of gum is found in other plants, and the generic name of *tragacanthin* is sometimes applied to it.

Tragedy (Gr. τραγῳδία). A species of drama, in which the diction is elevated and the catastrophe melancholy. The name is usually derived from the ancient Greek custom of leading about a goat in procession at the festivals of Bacchus, in whose honour those choral odes were sung which were the groundwork of the Attic tragedy. Some recent writers, however, have given a new explanation of the word τράγος, considering it an ancient Greek adjective, and translating it *melancholy* or *lamentable*. [COMEDY; DRAMA; THEORIC FUND.]

Tragi-comedy. In Literature, a compound name, invented to express a class of dramatic compositions which should partake both of tragedy and comedy. If the mixture of serious with humorous portions in the piece alone entitles it to this name, then all the plays of Shakspeare (with the single exception of the *Merry Wives of Windsor*, to which some add

the *Twelfth Night*) belong to this class; as do, indeed, almost all the works of the old English dramatists. But *Troilus and Cressida* alone, of the plays of Shakspeare, bears this title in old editions. French critics define the distinction to be, that the *event* of the tragi-comedy is not unhappy or bloody.

Tragus (Gr. τράγος). In Anatomy, the term applied to the small cartilaginous eminence at the entrance of the external ear; in the adult it is beset with small hairs.

Trail (Span. traillar, akin to Lat. traho, *to draw*). In Artillery, that part of a gun carriage which, in travelling, is hooked up to the limber, but when the gun is unlimbered for action, rests on the ground, forming a third point of support, the wheels being the two other points. It usually stands at an angle of 21° with the ground.

Trailbaston, Justices of. In English Legal History, an itinerant court, appointed towards the end of the reign of Edward I., to inflict summary justice on disturbers of the peace, and occasionally afterwards. The most probable conjecture represents the name as a popular appellation, descriptive of the long staves which the marshals of the court carried or *trailed* after them. This kind of special commission fell into disuse in the reign of Richard II.

Trajectory (Lat. trajectus, *thrown beyond*). The curve which a body describes in space; e.g. the orbit of a planet or comet, or the path of a stone thrown obliquely upwards in the air. The form of the trajectory depends on the initial velocity with which the body is projected, the law and direction of the forces which act upon it, and the resistance of the medium in which it moves. The planetary orbits would be strictly elliptical were it not for the disturbing forces which they exert on each other; and but for the resistance of the air, a body projected obliquely from the earth would describe a portion of a parabolic curve.

In Geometry, the term *trajectory* is usually applied to a curve which cuts all curves of a given system at the same angle. When the angle in question is a right angle, the curve is said to be an *orthogonal trajectory*. Thus, a loxodromic curve on any surface is a trajectory of one of its systems of lines of curvature, whilst a line of curvature of the other system is an orthogonal trajectory of the first. In plane curves, again, a logarithmic spiral is a trajectory of a pencil of rays through its pole, whilst a circle around that pole as centre is an orthogonal trajectory of the pencil. The problem of finding the trajectories of a given system of curves requires the integral calculus for it solution. If $F(\xi, \eta, a)=0$, in which a is supposed to be a variable parameter, represent the system of curves, then $\frac{d\eta}{d\xi}=f(\xi, \eta, a)$ will be the tangent of the inclination of any curve to the abscissa axis at the point (ξ, η). Let $\frac{dy}{dx}$ have the same signification with respect to the trajectory at a point (x, y) coincident with (ξ, η), then c being the tangent of the constant angle, the condition

$$f(x, y, a)\frac{dy}{dx}=c\left[1+\frac{dy}{dx}f(x, y, a)\right]$$

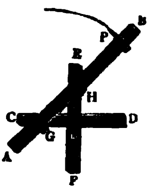
must be satisfied at the point where any trajectory cuts the curve individualised by a. Eliminating a by means of the relation $F(x, y, a)=0$, the differential equation of all the trajectories is obtained. For orthogonal trajectories the above condition reduces itself to $1+\frac{dy}{dx}f(x\,y\,a)=0$. Trajectories were first studied by John Bernoulli, and afterwards by James Bernoulli, Leibnitz, Sir I. Newton, Taylor, Euler, and others. Euler's three elaborate memoirs on the subject will be found in the *Novi Commen. Petrop.* vol. xiv. and *Nova Acta Petrop.* vol. i.

In a similar manner, a surface is said to be a trajectory of a given system of surfaces when it cuts the latter everywhere at the same angle. Orthogonal trajectories of this kind have been studied by Lagrange (*Berlin Memoirs*, 1779 and 1785), Euler (*Petersburg Memoirs*, vol. vii.), Dupin, and several others.

Trajectory. In Gunnery, the curved line described by the centre of gravity of a projectile in flight. [Gunnery; Projectile.]

Tram. [Silk.]

Trammel (Old Fr. tramel, the modern tramail). An instrument for drawing ovals, much in use among joiners and other artificers. It consists of a cross, C D E F, in which are cut two grooves at right angles to each other; and a beam, A B, carrying two pins, G, H (which are clamped to A B, and slide in their grooves), as well as a pencil, P: these parts are called the *cross* and the *beam*. By turning A B round, the pins G, H slide along the grooves, and the pencil P describes an elliptic curve. A demonstration of the properties of this instrument may be seen at p. 700, vol. xiv. of Hutton's *Abridgement of the Philosophical Transactions*.



Tramontane. [Ultramontane.]

Transcendental (Lat. transcendo, *I climb beyond*). In Algebra, a term applied to any quantity which cannot be represented by an algebraic expression of a finite number of terms with determinate indices. Such quantities include all exponential, logarithmic, and trigonometrical expressions. Thus a^x, $\log x$, $\tan x$, &c. are transcendental quantities; and any equation into which such quantities enter is called a *transcendental equation*, and any curve defined by such an equation is called a *transcendental curve*.

Transcendental. In Anatomy, the term has been applied to that branch which treats of the essential nature and homologies of the parts of the body, and the results of which

study seem to be different from, or beyond, what would be suggested by the ideas of the parts derived from the outward senses; as when the human blade-bone, which to the eye is very different from a human rib, and which is quite distinct from the skull, is seen by the mind to be the rib of the occiput.

Transcendental. A word used by German philosophers to express that which *transcends* or *goes beyond* the limits of actual experience. This general meaning is somewhat restricted by Kant, who draws a distinction between the *transcendental* and the *transcendent*. The transcendental he defines to be that which, though it could never be derived from experience, yet is necessarily connected with experience, and which may be shortly expressed as the intellectual *form*, the *matter* of which is supplied by sense. 'I call,' says he, 'all knowledge transcendental, which has regard in general not so much to *objects* as to our mode of knowing or apprehending objects (i.e. to formal knowledge), so far as this is conceived to be possible à priori. A system of such conceptions would be named transcendental philosophy, as the system of all the principles of pure reason.' The *transcendent*, on the contrary, is that which regards those principles as objectively real to which Kant assigns only a subjective or formal reality, and consequently is by him regarded as beyond the limits of the human reason altogether.

Transept (Lat. trans, and septum, *a place enclosed*). In Architecture, that portion of a church or other building which extends on the north and south sides of the area between the nave and the choir, and forming the short arms of the cross upon which the plan of cruciform churches is laid out.

Transfiguration (Lat. transfiguratio). This word is applied especially to the event recorded in Matt. xvii., Mark ix., Luke ix., where it is related that Christ took Peter, James, and John up into a high mountain, and was transfigured before them, His face shining as the sun, and His raiment glistering, while there appeared in conversation with Him, Moses and Elias. An ancient tradition assigns Mount Tabor as the scene of this event, upon which three contiguous grottoes have been fashioned to represent the three tabernacles which Peter desired to raise upon the mount.

Transformation (Lat. transformatio). In Algebra, transformation consists in replacing the variables or facients of a given expression by functions of another set of variables. When these functions are of the first degree in the new variables, the transformation is said to be *linear*. [Linear Transformations.] The *transformation of co-ordinates*, in Geometry, is a case of linear transformation. [Co-ordinates, Transformation of.]

Transformation, Tschirnhausen's. [Tschirnhausen's Transformation.]

Transfusion (Lat. transfusio, from fundo, *I pour*). The injection of blood from one living animal into another. It was at one time supposed that this operation might be resorted to, to sustain life in cases of great loss of blood from accidental hæmorrhages and other causes, and that in certain cases of mental and bodily disease a cure might be effected by abstracting a large quantity of blood, and supplying its place by transfusion from another person, or from an animal, such as a calf or sheep. Some of these experiments appeared at first to be attended with success, but bad consequences followed; and in two or three cases in which it was tried upon the human subject it proved fatal. Much was hoped from this practice, but it has now quite fallen into disuse.

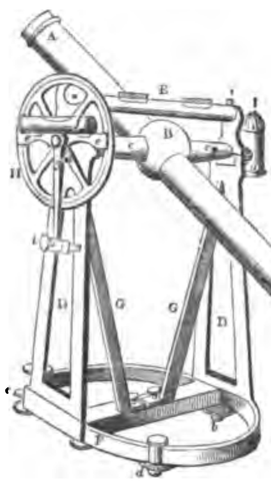
Transit (Lat. transitus, *passage*). In Astronomy, the culmination or passage of a celestial object across the meridian of any place. The determination of the exact times of such transits is one of the most important operations of practical astronomy, as it is by this means that the differences of right ascensions, and consequently the relative situations of the fixed stars, and the motions of the planets and comets in respect of the celestial meridians, become known; and it is most easily and accurately effected by the aid of the Transit Instrument, the nature and method of using which will be explained under that term.

Transit is also used to signify the passage of an inferior planet across the sun's disc. [Mercury; Venus.]

Transit Circle. [Transit Instrument.]

Transit Instrument, Transit Circle. The transit instrument, called by the French *instrument des passages, lunette méridienne*, consists essentially of a telescope firmly attached to a transverse horizontal axis, the ends of which are directed to the east and west points of the horizon. It is used primarily to note the *time* of passage of a celestial object across the meridian. In the *transit circle* we have a large circle added to the instrument, for the purpose of noting primarily the *altitude of the star* with the greatest accuracy as well as the time of its passage. The extremities of the axis of the telescope common to both instruments are formed into cylindrical pivots of exactly equal diameters, which rest in notches (technically called Y's, from their resemblance to that letter), formed in metallic supports, susceptible of nice adjustment both horizontally and vertically, so that the axis can be placed perfectly horizontal, and at right angles to the plane of the meridian in which the telescope moves. In the focus of the eye-piece is placed a system of three, five, or sometimes seven vertical and equidistant wires or spider-lines, generally crossed by two horizontal ones, between which it is convenient that the passage of objects over the central wires should be observed. By means of adjusting screws the diaphragm, or plate to which the wires are attached, is brought into such a position that the middle vertical wire intersects the optical axis of the telescope, in which position it is permanently fixed.

When the system of wires is brought into this position, the middle one will be a visible representation of that part of the meridian to which the telescope is directed; and when a star is seen to pass this wire, it is in the act of culminating, or *transiting* the celestial meridian. The instant of the transit is noted on a clock or chronometer, which is an indispensable accompaniment of the instrument; and in order to render the observation more certain, the instant at which the star passes each of the vertical wires is noted, when practicable, and the mean taken as the true instant of passing the central wire. The sidereal times at which certain principal stars pass the meridian of Greenwich (and consequently the meridian of any other place whose longitude from Greenwich is known) being given in the *Nautical Almanac*, the comparison of the time indicated by the clock and the time in the almanac gives the *clock error*; and by observing the same stars from day to day the *clock rate* is determined. In this



manner we are enabled to assign the exact interval of sidereal time between the transits of the different stars, and consequently the difference of the right ascensions.

The annexed diagram represents the *portable* transit instrument, as at present constructed by Troughton and Simms, when the telescope does not exceed twenty inches or two feet in focal length. The telescope tube AA is in two parts, connected together by a sphere B, which also receives the larger ends of the two cones *cc* placed at right angles to the telescope, and forming the horizontal axis. The axis terminates in two cylindrical pivots, which rest in Y's fixed at the top of the vertical standards DD. One of the Y's has a small motion in azimuth, by means of which the telescope can be adjusted to the plane of the meridian. A spirit level E, which is made to stride across the telescope and rest on the two pivots, serves to show when the axis is horizontal. The standards D D are fixed by screws upon a brass circle F, which rests on three screws, *b*, *c*, *d*, forming the feet of the instrument, and by which the levelling is performed. G G are two oblique braces for the purpose of steadying the supports. On the extremity of one of the pivots, which extends beyond its Y, is fixed a divided circle H, which turns with the axis; while a double vernier remains stationary in a horizontal position, and shows the altitude to which the telescope is elevated. The verniers are set horizontal by means of a spirit level *f*, and are fixed in their position by a brass arm *g h*, clamped to the supports. The whole of this apparatus is movable with the telescope, and when the axis is reversed can be attached in the same manner to the opposite standard. For the purpose of illuminating the wires when observations are made at night, one of the pivots is pierced, and admits the light of a lamp I, which is thrown upon the wires by a reflector placed diagonally in the sphere B. (Simms's *Treatise on Mathematical Instruments*.)

Several improvements, both in application and in construction, have recently been made in this important instrument. The principal new application is that by which it is made to determine the latitude of the place of observation, or the zenith distances of stars, by being placed at right angles to its ordinary position, i. e. with its line of collimation lying in the plane of its prime vertical. A large instrument of this class, called a *prime vertical instrument*, recently erected at the observatory of Pulkowa, serves to determine with admirable precision the zenith distances of stars which pass near the zenith of that observatory; and M. Struve considers its use to be of extreme importance in the ulterior investigations connected with aberration, precession, and nutation.

Mr. Simms produced at the Great Exhibition of 1851, a specimen of a *double-transit instrument*, i. e. an instrument which might be used with equal facility when placed in the meridian and in the prime vertical. This is effected by making the axis of the telescope itself convertible into a telescope by having an object-glass fitted into one of the pivots, and a sliding tube carrying an adjustible cross of delicate spider-lines with a positive eye-piece at the other pivot. The adjustment of the axis telescope is effected by a small collimator placed in a line with the axis. The axis is turned round, and the position of the wire-frame is shifted till the centre wire coincides with the mark equally well before and after reversion. If the meridian telescope be previously adjusted, it can be made use of for readily placing the axis telescope in its proper position for the determination of latitude by means of the transits of stars which pass the meridian near the zenith.

Another kind of transit instrument lately brought into use is the *diagonal* or *chamber transit*. The peculiarity of this instrument is, that the rays tending to form an image of a star, after passing through the object-glass, do not proceed in a straight line through the tube in the usual way, but, being received upon a speculum or prism placed in the axis, are turned aside through one of the axes, which is perforated and provided with an eye-piece and a system of wires. The inconvenience of placing the body in awkward positions for the observations of stars, so much felt in the use of small transits, is thus avoided, and the observer has no need to shift his position, whatever be the altitude of the star to be observed. Mr. Simms has succeeded in providing convenient means for the illumination of the field of view of the diagonal transit by the following method: The back pivot being also perforated has a small convex lens set within it, and a larger convex lens is fixed within the axis at the back of the reflector, of such a size that one or more segments near the edges project beyond the edge of the reflector. The light of a lamp placed outside the pivot is condensed by the small lens, and the rays after crossing diverge upon the large lens at the back of the reflector, the outer segments of which again condense it upon the field of view in sufficient quantity to produce a well-illuminated field.

Another improvement is the *prism illumination* of the field of view of transit instruments. It has always been a difficult problem for practical astronomers to provide for the observation of very faint objects, for which it is necessary to have the field of view dark and the wires illuminated. Various means, attended with only partial success, have been devised in different observatories, the most successful of which was till recently the application of the galvanic current. Mr. Airy applied for the first time the *prism-illumination* to the great transit circle at Greenwich, in the year 1850; and this method, which is equally remarkable for its simplicity and facility of application, is now applied to small instruments, and will probably supersede all other methods. A pierced reflector is placed as usual in the central part of the axis of the telescope; but this, instead of being fixed, has a motion round an axis, so that it can be placed at any angle of inclination to the tube, being acted on by means of a rod projecting through the eye end of the telescope tube near the observer's hand. If the rod be pulled out to its full length, the reflector stands at its usual angle of 45°, and the field is *fully illuminated* by the lamp placed at the axis. By pushing the rod, the reflector is made to stand more nearly at right angles to the tube; and the light, being thrown down the tube in smaller quantity, is thus *moderated*. Finally, when the reflector is at right angles to the tube, no light passes down it to the eye, but in this case the prism application comes into play. Four right-angled glass prisms are placed symmetrically round the ring of the reflector, one of the sides of each receiving the rays from the axis lamp perpendicularly. The light reflected from their hypothenusal sides, and passing perpendicularly through their remaining sides, is made to proceed parallel to the sides of the tube. It is then finally received upon four other prisms placed properly in the plane of the wires of the telescope, so as to be transmitted entirely in that plane, and to illuminate perfectly both sides of the vertical wires, and the upper and under sides of the horizontal wires. This process has been for some time used with perfect success for the illumination of the wires of the transit circle at Greenwich.

Adjustments.—In practice, the transit instrument is subject to three principal errors. 1st. The optical axis of the telescope may not be quite perpendicular to the axis of the instrument; which is called the *error of collimation.* 2nd. The axis may not be perfectly horizontal; which is called the *error of level.* And 3rd. The axis may not be exactly east and west, or the optical axis may not be exactly in the meridian; which is called the *error of azimuth.* The error of collimation is detected by pointing the telescope to a distant well-defined terrestrial object, and bisecting it by the middle vertical wire; the telescope is then lifted out of its supports and reversed (i.e. the end of the axis which was turned to the west is now turned to the east), and brought again to bear on the same object. If the middle wire is found to be still bisected, the adjustment is perfect; if not, the diaphragm is moved a little to the right or left by means of the adjusting screws, until the middle wire bisects the object in both positions of the axis. To place the axis exactly horizontal, the level E is suspended in the proper manner from the pivots, and the air bubble brought to the middle by means of the foot screws. The level is then reversed, i.e. the end which was turned to the west is now turned to the east; and if the air bubble still stands at the middle, the axis is horizontal; if not, the foot screws are adjusted until it stands at the middle in both positions of the level. To place the instrument exactly in the meridian, some knowledge of practical astronomy is required. It is easy to place it *nearly* in the meridian by the transit of the sun at apparent noon, or of any star whose right ascension is known; and when in this approximate position to the meridian, the deviation may be discovered and corrected in various ways. One of the simplest is to observe two successive transits of Polaris (or any circumpolar star) above and below the pole. If the interval between the two transits is exactly twelve sidereal hours, the telescope is exactly in the meridian; and the difference of the interval from twelve hours shows both the amount and the direction of the azimuthal error. A similar process may be used with a high star and a low star for showing whether the instrument deviates much in

azimuth, by comparing the difference of their imes of transit with the difference of their right ascensions. In the case of fixed instruments, a meridian mark is usually made on some distant object, and permanently established for the convenience of ready reference.

The transit instrument appears to have been invented by the Danish astronomer Roemer, by whom it was first described in 1700, in the *Miscellanea Berolinensia*, tome iii. Dr. Halley placed a transit instrument in the Greenwich Observatory in 1721, the telescope of which was about five feet in length; but it was little used until 1742, when Bradley commenced a regular series of meridional observations. The transit instrument till lately in use in the Royal Observatory is the workmanship of Troughton, and was set up in 1816. It has recently been superseded by the gigantic transit circle now in use.

The finest example of the *transit circle* is the meridian instrument erected at Greenwich, by the astronomer royal, Mr. Airy, in 1850; and, from the beginning of 1851, all the meridian observations have been made with it. It consists mainly of a telescope of 12 feet focal length, with an object-glass of 8 inches clear aperture, carrying on each side of its centre a circle of 6 feet diameter. The tube of the telescope is of iron cast in four pieces, viz. two immense cones at its eye end and object end, and a large central cube in two pieces, having attached to them in the same casts the pivots on which the telescope revolves. The cones weigh each about 1¾ cwt. and the central cube with its pivots weighs nearly 8 cwt. The two parts of the cube are bolted together on flanges with planed surfaces, as also are the cones to the central cube. The surfaces of the pivots were hardened after the casting, by chilling them to a depth of about a quarter of an inch, and were afterwards ground and polished to a true cylindrical form after a great expenditure of time and labour. The circles are carried on cylindrical rims on the east and west sides of the central cube. The western circle has a *dished* surface of about 3 inches in breadth with its concavity westward, and carries two bands, one on its eastern and one on its western surface, the latter being divided to 5′ of space. The eastern divisions are merely given for the convenience of setting the instrument accurately to given objects by means of a pointer; but the western divisions are for the observations of zenith distance. For the reading of the circle, six long microscopes are fixed in the solid stone of the western pier, having their object-glasses arranged in a circle of about 5½ feet diameter on the inner or eastern surface, and their eyepieces in a circle of about 2 feet in diameter at the back of the piers. The centres of these circles are in the same horizontal line with the centre of the telescope, and at the height of 5 feet from the floor. The microscopes, whose axes lie in a conical surface, are each 45 inches in length, and their axes are not quite perpendicular to the portions of the surface of the circle opposite to them, but are inclined in such a way that the light thrown through corresponding illuminating holes (cut in the pier) from a central gas lamp shall be reflected truly into them without the aid of specula. The error of collimation of the telescope is found by means of two 5-ft. telescopes, called *collimators*, one to the north and the other to the south of it, and the error of level is found by the observation of the reflected image of the central wire by means of Bohnenberger's eye-piece; by which means also, together with observations of stars by reflection, the zenith point is found. An apparatus is provided by which the instrument can be lifted at pleasure out of its Y's so as to be in the same state of strain when elevated as when resting in its Y's. This arrangement was considered necessary to enable observations of collimator by collimator to be made. This is now done by means of holes which have been pierced in the two corresponding sides of the cube. The apparatus for carrying the mercury trough, which usually contains about 60 lbs. of mercury, is ingenious, and motions are readily given to it either in a north and south, or in an east and west, direction.

For illumination of the wires with a dark field, eight prisms are employed. Four of these are arranged symmetrically on the reflector, which is placed at the centre of the telescope as usual, but which is movable round an axis, and can be acted upon by a rod passing through the tube of the telescope and having its end near the eye-piece; and four are arranged symmetrically in the plane of the wires in the eye-piece. By this means, when the field is dark or the reflector is at right angles to the tube, the light after reflexion by the two sets of prisms is thrown across the field in the plane of the wires, and illuminates them abundantly for observation.

The casting and the engineering generally for this instrument were conducted by Messrs. Ransomes and May of Ipswich; but the dividing of the circles, and all the optical part of it, were performed by Mr. Simms. The object-glass is also of his manufacture.

Messrs. Cooke and Sons have recently constructed a transit instrument for the Indian Trigonometrical Survey, in which they have introduced several new principles of great ingenuity and importance. Four swing levels are attached to the cube, by means of which reversals are rendered unnecessary. The means of adjustment, and the finish and detail of the parts, leave nothing to be desired.

Transition (Lat. transitio, *a passing over*). A term formerly used in Geology to designate a series of rocks now referred to the Palæozoic period. They were long regarded as representing a state of transition from the apparently unformed condition which the older rocks were believed to exhibit, to the more complete state of rocks of a newer period. The term is now rarely used in English works, though still met

with occasionally in foreign geological treatises, chiefly French.

Transitive Verbs. [VERBS.]

Transitory Actions. In English Law, actions in which the *venue*, i.e. place alleged in the declaration, is immaterial, and consequently the trial may be had in any county; opposed to *local actions*, in which the trial can only be had in the county where the alleged injury was committed. To the former class belong most personal actions. [ACTION; VENUE.]

Transitu, In (Lat. *in the act of passage*). In Law, goods are said to be liable to *stoppage in transitu* when detained by one having a right to do so in their way to their destination; as, by an unpaid vendor, in case of the vendee's insolvency. In international law, it is held that the property of parties belligerent cannot change its national character during the voyage from port to port, i.e. *in transitu*.

Translation. In Law, the removal of a bishop from one see to another.

Translation, Motion of. In Mechanics, the motion in virtue of which the several particles of a body describe equal and parallel right lines.

Translucency (Lat. transluceo, *I shine through*). Semitransparency. The term is chiefly used in Descriptive Mineralogy as applied to minerals which admit of a passage of the rays of light, but through which objects cannot be definitely distinguished.

Transmigration of Souls. [METEMPSYCHOSIS; PYTHAGOREAN.]

Transmutation (Lat. transmutatio, from muto, *I change*). In ALCHEMY, the pretended operation of changing the imperfect metals (as they were termed) into the two precious metals, gold and silver.

TRANSMUTATION. In Geometry, the change of one figure or body into another of equal area or solidity; as a triangle into an equivalent square, a sphere into a cube, &c.

Transom (Lat. transenna). In Architecture, the horizontal piece framed across a double-light window: when a window has no transom, it is called a *clere-story* window.

Transoms. In Shipbuilding, beams bolted across the sternpost, to receive the after ends of the several decks, and to give form to the stern.

Transparency. That quality in certain bodies by which they give passage to the rays of light. It is generally supposed to be a consequence of the homogeneity of the matter of which they are composed.

Transpiration (Lat. trans, and spiro, *I breathe*). Gases exhibit peculiar properties in passing through tubes of very small diameter. The rates at which they flow through such tubes vary with the composition of the gas, but bear a constant relation not coinciding with density, diffusion, or any other known property. These fundamental peculiarities are termed by Graham those of transpiration. The experiments by which they were established were analogous to those of Poiseuille and Regnault on the efflux of liquids through tubes of great length in comparison with diameter. The transpiration of a gas is uninfluenced by the material of which a tube is constructed; it increases with pressure—the greater the density, the shorter the time of transpiration; it is inversely proportionate to the length of the tube; slower at low than at high temperatures. Oxygen has the slowest rate of transpiration, and may be taken as the unit for purposes of comparison, $=1$; chlorine is 1·5; hydrogen 2·288. Graham considers that transpiration is probably the resultant of a kind of elasticity depending on the absolute quantity of heat, latent as well as sensible, which different gases contain under the same volume.

Transplanting (Lat. transplanto, *to transplant*). The art of removing a plant or tree from one situation to another in such a manner that it may continue to grow. The operation is commonly performed in the winter season, or in autumn and spring, when plants are generally in a dormant state; and the great object of the transplanter is to lift as many of the roots as possible without injuring them, and to replace them in a new situation to which the tree is transplanted in such a manner as to facilitate their growth. With herbaceous plants and young trees this is comparatively a simple operation; but with large trees it is an operation of skill, care, and labour.

When a large tree is to be transplanted, it should be considerably under the normal age of the species; and to prepare it for the change which it is to undergo, other trees, or objects of its own height with which it is surrounded, should be taken away a year or two previous to removal, in order to accustom it to the direct action of the light and air on every portion which is above ground. The next part of the operation is to dig a trench round the tree equidistant from the trunk, at the distance of three, six, nine, or twelve feet, according to its height, and to such a depth as to cut through all the horizontal roots. The tree may then be removed to its new situation, with or without the earth attached to that part of the roots which remain; or (which is a more certain mode) the trench may be left open during a year, in order that the sections of the amputated roots may heal over, and be prepared to emit new fibrous roots after the tree is transplanted; or (which is the more general mode) the trench may be filled up with finely pulverised soil, in order to encourage the production of fibrous roots; and at the end of a year, or of two years if the tree is very large, it may be removed to its final situation. The earth should be filled in carefully and made firm about the roots, which should be spread horizontally in all directions. In a moist climate, the branches may all be retained; but in dry climates, it may be desirable to thin them out moderately; this pruning should, however, never be carried to excess.

The proper season for transplanting all ligneous deciduous plants, whether small or

large, is early in autumn, after the leaves have dropped. In the cases of kitchen garden plants and others of herbaceous habit, where it is done at any season, transplanting is most successful if carried out in showery weather. Evergreen trees may also be transplanted in the autumn, but with equal success in early summer after growth has commenced.

As a general rule, it may be stated, that the less damage sustained by the smaller roots and their fibrils, the more successful will be the operation. The chief further precaution is to check excessive evaporation from the leaves, so that their healthy action may be maintained.

Transport (Lat. trans, and porto, *I carry*). A vessel employed by government to convey stores, troops, &c.

Transportation (Lat. transportatio, *a carrying across*). In Law, a species of punishment. It is not known to the common law of England, and was originally a commutation of punishment, pardon being granted to offenders of various kinds on condition of undergoing transportation: generally for seven or fourteen years, or for life. It was till lately a statutable punishment for a great variety of offences. It is said to have been first inflicted as a punishment by 39 Eliz. c. 4, enacting that such rogues as were dangerous to the inferior people should be banished. At that time the English plantations in North America were the receptacles of transported convicts. Virginia, the Jerseys, Delaware, Maryland, &c. are the districts which received the greatest accession to their population in this way. At the very commencement of the practice, the same arguments were employed against it by Lord Bacon which are urged at this day by many law reformers. 'It is,' he says, 'a shameful and unblessed thing to take the scum of people, and wicked condemned men, to be those with whom you plant.' It was not, however, brought into general use as a punishment until 1718, by 4 Geo. I., which Act gave the courts a discretionary power to banish to the American plantations felons entitled to benefit of clergy. After the loss of the greater part of our American colonies, several years elapsed before the government fixed on any place by way of substitute. At length, in 1787, Botany Bay, on the coast of New South Wales, was fixed upon: 760 convicts were despatched that year. But when the expedition arrived, it appeared that Botany Bay (discovered by Cook in 1770) afforded no practicable site for the colony; which was consequently landed at Port Jackson, where the town of Sydney was founded.

In a few years afterwards, convicts were also transported to Van Diemen's Land (now Tasmania), and these two colonies continued for a long period to be the only, and were always the principal, recipients of our convicts. Two committees sat on the subject of transportation in 1838 and 1839, and from the publication of their reports an unfavourable view of the punishments which had hitherto been popular with the governing classes in England originated. Convicts at that time were disposed of either by *assignment*, under a kind of compulsory servitude to masters; in the service of government; in the road and chain gangs; in the penal settlements; in chain gangs in the penal settlements. The evidence taken before the committee in question led many to believe that while *assignment* was ineffective, by reason of its uncertainty and general absence of restraint, the *penal settlements* (Norfolk Island in particular) were replete with evil from the demoralisation engendered by them. Various schemes were consequently suggested, and partially tried, for amendment of the system, such as *tickets of leave*, which entitled the criminal to work for whom and where he pleased, provided he remained within the limits of his sentence; *exile*, under which a convict underwent part of his punishment at home, and the remainder under favourable conditions in a penal colony; *conditional pardons*, under which the convict became free for all purposes except that of returning to England. But of these and other devices little can be said, because they were never fully tried, the conflict between the Australian colonies and the mother country between 1850 and 1854 on the subject of transportation having ended in its abolition in 1857 (20 & 21 Vict. c. 3. s. 2), and the substitution of PENAL SERVITUDE. The sentence of penal servitude itself, may, however, be carried out (as regards males) by employment on public works out of the country, the present establishments for which purpose are at Bermuda and Gibraltar.

Although the subject has ceased for the present to be of practical importance in this country, yet it is impossible to say how soon the pressure on society occasioned by the secondary punishments now substituted for it may not cause it to be resorted to again.

As compared with the best regulated systems of imprisonment: 1. In respect of its effects on the convict himself; it may be doubted whether in the Penitentiary, on either the silent or the separate system, the mind of the majority of sufferers goes through a more wholesome process than in the penal settlements, notwithstanding all that we have heard even of the frightful condition of Norfolk Island, which was not an ordinary sample. 2. In respect of its effects on the ill-disposed population at home; the experience of anyone conversant with courts of justice will decide which sentence appears to produce the greatest impression when announced—imprisonment or banishment. And it must not be forgotten that it is not the real severity, but the action on the imagination, which deters from crime: the worst inflictions of the gaol are thought little of by anyone except the sufferer, while the evils of expatriation are greater in idea than in reality. 3. In respect of the ultimate reform of the offender; transportation pos-

sesses an incalculable advantage over every other secondary punishment. The convict who has undergone it begins life afresh: he remains, indeed, under some disabilities, sufficient to mark the sense entertained by society of the difference between him and the man unstained by crime; but there is nothing to prevent his rising by regular and honest conduct, if he chooses, into a station of comfort, and even of respectability. The man who leaves a gaol is utterly ruined. Society has devised, and perhaps can devise, no means of extending to him a jus postliminii, and bringing him back within the pale of citizenship.

Transposition (Lat. transpositus, part. of transpono, *I change the place*). In Algebra, the transposing of a term from one side of an equation to the other. It is in effect the adding of equal quantities to or subtracting equal quantities from each side of the equation, the *sign* of the quantity being changed from + to −, or from − to +. For example, if $a+x=c-d$, by transposing a we have $x=c-d-a$; or if $a+b=c-x$, by transposing x and $a+b$ we get $x=c-a-b$. The object of transposition generally is to bring all the unknown terms to one side of the equation for more conveniently finding their value with respect to the known terms.

TRANSPOSITION. In Music, the change which takes place by performing the same melody in a higher or lower key.

Transubstantiation (Lat. trans, and substantia, *substance*). The doctrine held by the church of Rome, that in the Eucharist the bread and wine are annihilated and replaced by the body and blood of Christ. In one of its liturgical offices its says, 'This *is not bread*, but God and Man, my Saviour.' By the opponents of the church of Rome it is maintained that this dogma is not found in Scripture, or in the writings of the fathers, or in the canons of the early church.

Transudation (Lat. trans, and sudo, *I transpire*). The oozing of fluids through membranes, or through porous bodies. The process is carried on by means either of ENDOSMOSIS or of EXOSMOSIS.

Transversal (Lat. transversus). In Geometry, the name given to a line (whether straight or curved) which *traverses* or intersects any system of other lines; as when a straight line intersects the three sides of a triangle. The properties of straight and circular transversals are discussed by Carnot, in his *Géométrie de Position*, and *Essai sur la Théorie des Transversales*.

In the former of these works, Carnot establishes the following general theorem, which, on account of its numerous applications, deserves enunciation. Let a_1, a_2, &c. . . . a_n be the points in which the side opposite the angle A of a triangle ABC is cut by a transversal curve of the n^{th} order; b_1, b_2, . . b_n the points in which the same curve cuts the side opposite B; and c_1, c_2, . . . c_n the points in which it cuts the side opposite C, then—

$$\frac{a_1B}{a_1C}\cdot\frac{a_2B}{a_2C}\cdots\frac{a_nB}{a_nC}\cdot\frac{b_1C}{b_1A}\cdot\frac{b_2C}{b_2A}\cdots\frac{b_nC}{b_nA}\cdot\frac{c_1A}{c_1B}\cdot\frac{c_2A}{c_2B}\cdots\frac{c_nA}{c_nB}=1,$$

provided a segment such as $m\,n$ be considered as positive or negative, accordingly as the direction from m to n coincides or not with that in which the perimeter of the triangle is conceived to be described. Carnot's theorem is, in reality, more general than the above, having been extended by him to any polygon whatever. When the transversal is a right line, Carnot's theorem gives the well-known one of Menelaus—

$$\frac{a_1B}{a_1C}\cdot\frac{b_1C}{b_1A}\cdot\frac{c_1A}{c_1B}=1,$$

the converse of which is also true. The correlative theorem and its converse is ascribed to the Italian Ceva: viz. If transversals be drawn from the angles of a triangle through the same point of the plane so as to cut the opposite sides in a, b, c, then—

$$\frac{a\,B}{a\,C}\cdot\frac{b\,C}{b\,A}\cdot\frac{c\,A}{c\,B}=-1.$$

Upon these two theorems Chasles bases his two systems of point, and line co-ordinates. (*Géométrie Supérieure*.) As a further illustration of the power of Carnot's theorem, which is itself founded on one of Newton's (*Enumeratio Linearum Tertii Ordinis*), suppose the transversal to be a cubic and the triangle to be formed by its three stationary tangents, whose corresponding points of inflexion are at a_1, b_1, c_1, respectively, then—

$$\frac{a_1B^3}{a_1C^3}\cdot\frac{b_1C^3}{b_1A^3}\cdot\frac{c_1A^3}{c_1B^3}=1;$$

so that, taking the cube root of both sides, we learn that the three points of inflexion of every cubic must lie in a right line. Or, again, let a transversal cut a cubic in a, b, c, and let ABC be the triangle formed by the tangents at the points of intersection; then BC will meet the cubic again in a point a_1, the tangential of a; CA will meet it in b_1, the tangential of b; and AB in c_1, the tangential of c [TANGENTIAL], in such a manner that—

$$\frac{aB^2}{aC^2}\cdot\frac{a_1B}{a_1C}\cdot\frac{bC^2}{bA^2}\cdot\frac{b_1C}{b_1A}\cdot\frac{cA^2}{cB^2}\cdot\frac{c_1A}{c_1B}=1;$$

but by hypothesis the product of the squared fifth ratios is unity, hence also that of the others must be so, and the three tangentials must lie in a right line.

Transverse Axis. In Conic Sections, the diameter which passes through both foci. It is the longest diameter in the ellipse, the shortest in the hyperbola; and in the parabola it and all the other diameters are infinite. [CONIC SECTIONS.]

Trap-rock. When Geology was first studied, a number of rocks were found to be similar in general appearance and composition, while all were remarkable for being spread out in

tabular or flat masses, one such flat mass extending beyond another, so that there was a rough resemblance to stairs. These rocks were hence called by a Swedish author *trappa*, the Swedish word for steps or stairs, and the name *trap* has ever since been received in reference to these. They have lông been recognised as belonging to the class seen in volcanic countries, and generally called *lava*, being, in fact, the melted material poured out from an active volcano in the state of a thick paste, and spreading itself over the surface adjacent. A succession of eruptions produces a series of steps; and where no volcano now exists, the old erupted lavas often remain. Of the various tabular erupted rocks thus named, *basalt* is the most distinctly an ancient lava, and is the most important. *Greenstone, whinstone, toadstone* (todtstein), and others, are names of varieties of basalt, and are also trap-rocks. [BASALT.]

The following may be selected as illustrative instances of the aspects, characters, and situations of trap-rock: Under the name of *greenstone* it is seen in characteristic masses, associated with the granite, mica-slate, and serpentine of the Lizard Point in Cornwall. Near Kington and Radnor in Wales, it accompanies clay-slate and old red sandstone; and upon the northern side of Snowdon, Plynlimmon, and Cader Idris, coarse-grained, and with regular crystals of hornblende in one place, and in another fine-grained, homogeneous, and even basaltic or columnar. In Derbyshire, under the name of *toadstone*, this rock is associated with mountain limestone, and with new red sandstone or red marl in the coalfields of the north of England and elsewhere. In Antrim we find it variously blended with the sandstone and chalk, and even sometimes superior to the newest secondary formations. These instances will serve to show the varied position of these rocks. In regard to their aspects, we observe them in Cornwall forming blocks and masses, not unlike the granite of the country. Sometimes, as in the coalfields, they form immense walls or dikes, and even axes of elevation; sometimes, as in Derbyshire, they have the appearance of stratification. In the Isle of Mull and elsewhere, they are massive and amorphous, and in many places columnar. The coast of Antrim, the island of Staffa, and some parts of Mull furnish magnificent instances. The Isle of Mull, Ulva, and the Tresharnish Isles exhibit trap rocks and veins in the greatest variety; and the veins of the Isle of Skye are remarkable not only for their singular extent and arrangement, but for the changes effected by them upon the rocks which they penetrate, and which are of such a nature as to throw some light upon the chemical phenomena connected with geology. Two of these veins penetrate the white marble of Strath. At their junction, the trap passes into a substance resembling serpentine, and is penetrated by fissures containing steatite; while the marble acquires all sorts of colours, and changes in composition from argillaceous to magnesian, and from magnesian to silicious. In other parts, the trap veins exhibit the several varieties of greenstone, basalt, and amygdaloid.

Very much more extensive and important masses of trap-rock are to be found in India, where the most singular results are produced by subsequent partial breaking-up by water action. Something of the same kind, but on a smaller scale, is exhibited in the Auvergne country in Central France.

Trap-tree. A species of *Artocarpus*, which furnishes a gutta or glutinous gum, used as birdlime in Singapore.

Trapa (abridged from Mod. Lat. calcitrapa, *caltrops*). A genus of *Haloragaceæ*, consisting of floating plants, chiefly natives of India, China, and Japan. The singular four-horned fruits of the European species, *Trapa natans*, which was the only one formerly known, have been compared to the spiked iron instruments called *caltrops*, employed in ancient warfare for strewing on the ground to impede the progress of cavalry; and, as growing in water, the plant is commonly called the *Water Caltrops*. The seeds of all these plants abound in starch, and are much eaten as food. Those of *T. natans* —called *Jesuits' nuts* at Venice, and *Chataigne d'Eau* by the French—are ground into flour and made into bread in some parts of Southern Europe. In Cashmere those of *T. bispinosa*, the Sinhara of the natives, feed 30,000 persons for five months in the year, and are so extensively collected that the celebrated Runjeet Singh of Lahore derived a revenue of 12,000*l.* per annum from them. *T. bicornis*, the Ling of the Chinese, has a fruit like a bull's head, and its seeds are also a considerable article of food.

Trapezium (Gr. τραπέζιον, *a small table*). In Histology, a small transverse band of fibres, which has been discovered in the brain of most mammalia and in the apes, behind the pons, at the origin of the seventh and eighth pairs of nerves. It was considered to be absent in man, but its presence has been recently demonstrated by Lockhart Clarke.

Trapezium and Trapezoid. In Geometry, an ordinary quadrilateral figure is sometimes called a *trapezium*; when two of its sides are parallel without being equal, it is called a *trapezoid*. The following properties of a trapezium may be mentioned: 1. The sum of the squares on the sides is equal to the sum of the squares on the diagonals, together with four times the square on the line joining the middle points of the diagonals. 2. This line joining the middle points of the diagonals is bisected by, and bisects the line joining the middle points of any two opposite sides. Hence it follows that the lines joining, in order, the middle points of the sides form a parallelogram. 3. The centre of gravity of the *surface* of the trapezium coincides with that of the triangle, two of whose sides are the diagonals, and the third side connects the points on these diagonals which are at the same distances

from the corners of the trapezium as is the intersection of the diagonals themselves. 4. A circle can be described about a trapezium if its opposite angles are supplemental, or if the sum of the rectangles under the opposite sides is equal to the rectangle under the diagonals. The converse propositions also hold. 5. A circle can be inscribed in a trapezium, if the sum of one pair of opposite sides is equal to that of the other pair, and conversely.

Trapezius. In Anatomy, a muscle situated immediately below the integuments of the posterior part of the neck and back. Its principal action is upon the scapula; and it also acts upon the neck and head, drawing the latter backwards, and turning it on its axis.

Trapezoides (Gr. τραπεζοειδής). In Anatomy, the *trapezoides* is the second bone of the second row of the carpus.

Trappists. The name of a religious order which still exists in Normandy. It was founded in 1140 by a count de Perche, in a deep valley called La Trappe (whence the name of the order), and has survived all the changes and revolutions of France. The rules of this order are of the strictest kind. It was, however, far less celebrated under its original foundation, than from the reform which it underwent under the celebrated abbé de Rancé, in the reign of Louis XIV. The history of this celebrated man is well known: he was a gallant and daring profligate, whose conversion was owing to the sudden death of a mistress. His character and reform were a favourite subject of discussion in the court of that king in its last and devout period; and he was himself the fashion, and much consulted and thought of by the fashionable devotees of the time. Perhaps the best notices of him will be found in the *Memoirs* of Saint Simon, who reverenced him, but was too clear-sighted to idolise anyone. His rule was of the austerest sort, enjoining, among other severities, absolute silence for a considerable period. At the Revolution, the community of La Trappe was dispersed: many members escaped to England, and were received by Mr. Weld, the owner of Lulworth in Dorsetshire. There are now several congregations of Trappists. Many of the stories told of the austerities of La Trappe—e.g. that each of the monks is employed in digging every day a portion of his grave, &c.—are fables. But the main features of the discipline, the enforced silence, and the complete seclusion from the world, are as commonly reported.

Traumatic (Gr. τραῦμα, *a wound*). Relating to wounds; hence the traumatic balsams and ointments of old pharmacy.

Traveller. In Naval affairs, a ring or hoop which slides along a rope or spar.

Traveller's-tree. One of the names of *Urania speciosa*.

Traverse (Lat. transversus, *laid across*). In Fortification, short earthen parapets placed at intervals between the guns in a field-work, or across the terreplein of the covered way of a fortress, &c., are called *traverses*.

Traverse. In Law, a name given to a plea containing a denial of some matter of fact alleged on the other side, and offering to refer the matter to the decision of a jury. [Pleading.]

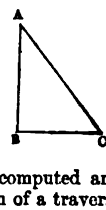
In cases of misdemeanour, where the defendant postponed the trial of the indictment until the next sessions or assizes, he was said to traverse the indictment, but this proceeding was abolished by stat. 14 & 15 Vict. c. 100, by which other provisions for the adjournment of trials were made.

Traverse Sailing. In Navigation, sailing on different courses in succession. The method of reducing such compound courses and distances into an equivalent single course and distance is called *resolving a traverse*. The reduction may be effected either by geometrical projection or trigonometrical computation; but it is generally performed by inspection with the aid of a Traverse Table.

Traverse Table. In Navigation, the tabulated form in which the northing, southing, easting, and westing are made on each individual course and distance in a traverse, for the purpose of finding readily the difference of latitude and departure made upon the whole; the difference between the sums of the northings and southings being the *diff. lat.*, and between the sums of the eastings and westings the *departure*.

The northing, southing, easting, and westing are generally taken by inspection from a table which contains the parts of a right-angled plane triangle corresponding to a given acute angle, and a hypothenusal line of every unit in length from 1 to 300, and sometimes to 500; an extent sufficient for the wants of the practical navigator. This table itself is also called a *traverse table*, from the facility which it affords in resolving a traverse; but it may be applied advantageously to many other purposes.

In the annexed figure, A B C is a plane triangle right-angled at B; and if A B represent a portion of the meridian (considered a straight line), passing through A, and A C the distance from A to C, then the angle A is called the *course*, A B the *difference of latitude*, and B C the *departure*; and to given values of A and A C the corresponding values of A B and B C, being computed and entered in a table, form a portion of a traverse table.



The table is thus constructed to A C and angle A as *arguments*, the angle being taken to every degree and every quarter point of the compass, and the hypothenuse to every integer from unity to as high a number as may be thought requisite. But, the table being formed, any two elements which geometrically determine the triangle may be assumed as the given one, and the other found by inspection from the table. But the use of the table is not limited to the solution of right-angled triangles only; for every case of oblique triangles may be solved by means of it.

Traversers. [RAILROADS.]

Traversing Platform. In Artillery, a platform to support a gun and carriage, which can be easily traversed or turned round a real or imaginary pivot near the muzzle by means of its trucks running on iron circular racers, let into the ground; there are *common*, *dwarf*, and *casemate* traversing platforms.

Travertin. A white calcareous stone, formed by the action of mineral springs either at the bottom of water upon the mud and other material there accumulated, when they issue under water, or thrown down from chemical solution in the waters of such springs in sheets or strata, when the waters thus loaded approach the surface of the ground and enter into new combinations.

Travertin is a modern deposit extremely abundant in volcanic districts. It is, however, not confined to recent volcanic districts, being abundant near extinct volcanoes and traceable elsewhere. Those springs often called *incrusting springs* or *petrifying wells* are such as form these deposits. Loaded with carbonate of lime, and continuing to flow from century to century, they are capable of producing results in the way of deposit very much larger than could be thought possible.

So large is the deposit of travertin in the Italian peninsula, where it has been chiefly observed, that the whole ground in some parts of Tuscany and the slopes of many of the hills are thickly coated with it or TUFA, so that the ground sounds hollow under the feet. As much as thirty feet thick of such accumulation has been deposited at the baths of San Filippo in twenty years, and here medallions or casts of coins and other objects are rapidly made.

It is not unusual to observe a perfect concentric structure in the travertin, showing the mode of its formation in successive layers. Small oolitic and pisolitic structure is also thus obtained. [OOLITE; PISOLITE.] Horizontal beds of tufa and travertin are seen at Tivoli from four to five hundred feet in thickness. [TIBER STONE.]

Travertin furnishes a good durable building stone, which was much used by the ancient Romans.

Travestie (Fr. travestir, *to disguise*). In Literature, a word used in the same signification as parody. [PARODY.]

Treacle (Fr. thériaque; Span. triaca; Gr. θηριακά, sc. φάρμακα, literally *remedies against the bits of beasts*). The viscid brown syrup which drains from the sugar in the refining moulds. Its specific gravity is generally 1·4, and it contains on the average 75 per cent. of solid matter. (Ure's *Dictionary.*)

Treadmill. An invention for giving hard labour to persons imprisoned for crime.

Its usual form is that of a cylindrical wheel of about 5 feet diameter, and 16 feet long; and many such wheels are sometimes coupled together. The circumference is furnished with twenty-four equidistant steps, on which the prisoners are made to work on the mill. Each individual treads in a separate compartment, boarded off so that no intercourse can take place between the parties at work at the same time.

All mounting the first step together, their weight sets the wheel in motion, bringing down the step trod upon; when they step up to the next one, which descends in the same manner, and so on, producing a continuous rotatory motion in the wheel, which may be applied as the moving force to a mill for grinding corn, or in turning any other machinery.

The prisoners at work on the wheel are assisted and supported by a hand-rail before them. The wheel makes about two rounds per minute, which is equivalent to a vertical ascent of about 32 feet per minute, and this is about the maximum of labour usually permitted on the wheel. These machines were introduced into all the great prisons in England and Wales; but in some cases a crank handle, which the prisoner is made to turn, is now employed in preference.

Treason or **High Treason** (Fr. trahison; Lat. traditio, *a betrayal*). By the statute 25 Edw. III. c. 2, the limits of this great offence were first accurately defined; and although subsequent enactments at different periods widely enlarged the range of actions which might be drawn within its penal character, yet most of these have been regarded as encroachments upon the principles of our jurisprudence. To compass the death of the king, queen, or king's eldest son and heir; to violate the king's wife or daughter, or the wife of the heir apparent; to levy war against the king in the realm; to assist the king's enemies in the realm or elsewhere; to counterfeit the king's privy seal; to counterfeit the king's money; to slay the chancellor or other high judicial magistrates; these are the seven species of treason constituted by this Act. The many fresh species devised during the troubled periods which followed that reign, and by the arbitrary genius of Henry VIII., were repealed in the first year of the reign of Queen Mary. Of new treasons since created by analogy to those which were previously so considered, the principal now remaining are those directed against the impugners of the Act of Settlement; and against persons intending the death, &c., of the sovereign, and declaring such intention by printing, writing, or overt act. (4. Steph. Bl. 245.) To counterfeit the king's seal or money is not now treasonable. The law relating to the manner of trial in treason is in many respects peculiar; the barbarous adjuncts to capital punishment in such cases have been long disused. By a recent statute (11 & 12 Vict. c. 12), commonly called the Treason Felony Act, under which the maximum punishment is penal servitude for life, many treasonable offences may be tried and punished as simple felonies.

Treason, Misprision of. This crime is defined to be the bare knowledge and concealment of treason, without any degree of

consent thereto; for any assent makes the party a principal traitor. [MISPRISION.]

Treasure Trove. By the Common Law of England, all gold and silver plainly derelict by the former owner, and not traceable to any representative of that owner, was the property of the crown. The rule, it appears, is derived from the strictly limited character of all feudal grants. The king's gift never conferred larger rights than were actually expressed; and hence, when, as in some manors, more enlarged powers or rights were conferred than was customary, such special advantages were always expressed, and never implied. In general, then, a grant only bestowed a permanent usufruct of the soil, the inferior metals being included under the ordinary right to dig or commit waste, while the more precious metals were reserved to the crown.

The duty of investigating all cases of treasure trove was one of the functions of the coroner, an exceedingly important officer in the middle ages, who was bound to be faithful to the crown in whose interests he acted, but who, being elected by the freeholders of the county, in much the same way that the seneschal of a manor was often elected by the free tenants, was in one sense independent of the crown.

For a long time the importance of treasure trove as an object of revenue has declined, and the privilege of the crown, having become odious since public opinion has recognised a larger ownership in land than is consonant with the feudal theory, has seldom been exercised, except to secure antiquities and rare coins for the British Museum. These, we believe, it has always purchased at a valuation from the finders or owners.

The Treasury has now power to remit the crown's rights in treasure trove. The security of property which we have enjoyed since the Revolution has, however, put a complete stop to the practice of burying treasure in Great Britain. But down to a late period the practice was common in Ireland, and is, perhaps, not yet altogether abandoned in that country; and it is also common in some of the Continental states. Neckar mentions that in France, under the ancien régime, the vassals of many of the nobles, afraid of subjecting themselves to the violence of their masters, buried all the money they could scrape together; and during the anarchy and brigandage of the Revolution, vast sums were thrown into the earth. The well-informed Russian economist, M. Storch, mentions that the practice of burying treasure is still extremely prevalent in Germany, Italy, and Russia; and it must necessarily be more or less prevalent in every country exposed to the ravages of war, or where the rights of property are imperfectly protected. But it is chiefly in the despotic states of Asia, and in Turkey in Europe, that the burying of money is carried to the greatest extent. *There* every individual estimates his wealth, not by the stock or capital he has lent to others, or has employed in the great work of production, but principally by the amount of the treasure he has been able to conceal; and every poor man deposits in the earth whatever he can contrive to withdraw from the grasp of his avaricious masters. Mr. Scrafton, in his valuable tract on Hindustan, considers that the universality of this practice, and the quantity of the precious metals which must in consequence have been lost, have been a principal cause of the long-continued drain of specie to the East. From the discovery of the American mines down to a very late period, the greatest portion of their produce has been directly or indirectly exported to Turkey, Hindustan, and other Eastern countries; and yet it is said that the precious metals do not seem to have become more abundant in those countries, or the prices of commodities to be materially increased. But, without attempting to investigate the precise degree of credit that ought to be attached to this statement, it is abundantly certain that the want of security which has caused this locking up of so large a quantity of capital must be one of the main causes of the poverty and wretchedness in which the people of India, Persia, Turkey, &c. are involved.

Treasurer, Lord High (Fr. trésor, Span. tesoro, Gr. θησαυρός, *treasure*). Formerly the third great officer of the crown in England. The office is now executed by five persons, styled the *lords commissioners of the treasury*. [TREASURY.]

Treasury, Board of. In England, the board to which is intrusted the management of all matters relating to the sovereign's civil list or other revenues. This office was formerly committed to the lord high treasurer; but in modern times a lord high treasurer has not been appointed, the duties of his office being executed by a board of five lords commissioners. The chief of these, or first lord of the treasury, is generally the prime minister for the time being; his office, however, in relation to the department itself, is little more than nominal; its practical head being the Chancellor of the Exchequer. The salary of the first lord of the treasury is 5,000*l.* per annum; that of the Chancellor of the Exchequer is of the same amount; the three junior lords have 1,000*l.* a year each. There are two joint secretaries of the Treasury, one of whom manages the details of ministerial business in the House of Commons, and is familiarly termed the *whip*.

Treating (Fr. traiter, Lat. tracto, *to handle*). Treating at parliamentary elections, by corruptly providing meat, drink, entertainment, or provision, is now a substantive offence, punishable by a fine of 50*l.*, besides being a ground for avoiding the election. (Stat. 17 & 18 Vict. c. 102, and amending Acts.)

Treaty (Fr. traité; Ital. trattato, from Lat. tractatus, *a handling*). In Law, an agreement between two or more independent states. Grotius (*De Jure Belli et Pacis*, l. ii. ch. xv. s. 5) divides treaties into two classes: those which turn on things to which the contracting parties are already bound by the law of nature,

such as mutual amity, commerce, &c.; and those which contain stipulations for something more, such as treaties regulating boundaries, conceding particular powers, &c. The municipal constitution, in every state, determines in whom resides the authority to make and to ratify treaties. In most monarchies it is vested in the sovereign; in republics, in the chief magistrate, senate, or executive council; in federal states, sometimes exclusively in the federal authority, as in the United States; but in the Germanic federation (while existing) the particular states retained the right of making treaties of alliance and commerce not inconsistent with the fundamental laws of the confederation. In order to enable a public minister or other diplomatic agent to conclude and sign a treaty, he must be furnished with a full power; and when so concluded, the treaty is binding on the state, in the same manner as an agent is bound by the act of his principal. But the question how far, and in what cases, ratification is necessary, has been the subject of much debate among writers of international law. It is usual to reserve a power to ratify in the treaty itself. It is necessary also, in most constitutional governments, that the sanction of the legislative body should be subsequently given to treaties of commerce, or treaties imposing taxes on the people, entered into by the executive. Thus the government of Great Britain, when making treaties, granting subsidies, &c., usually stipulates that the sovereign will recommend to parliament to make the grant necessary for the purpose; but under the constitution of the United States, it has been thought that congress is bound to sanction treaties in general made by the president with the advice and consent of the senate. Treaties have been divided into *real* and *personal*: the former of which are said to bind the contracting parties, independently of any change of the sovereign or the rulers of the state; the latter are made with express reference to the person of the actual ruler. But treaties properly so called, as of friendship and alliances, commerce and navigation, even if perpetual in terms, are said to expire: 1. In case either of the contracting parties cease to be an independent state; 2. When the internal constitution of government is so changed as to render the treaty no longer applicable. In this they differ from what are called *transitory conventions*, which pass from one government to another; such as treaties of cession, boundary, &c. (Wicquefort, book ii.; Vattel, book ii.; Schoell, *Hist. de Traités de Paix*, 4 vols. Brussels 1817.)

It was at one time an international custom that belligerents should, on the breaking out of a war, make a public and solemn proclamation that the obligation of treaties between them had ceased. That custom has become obsolete. In its place has arisen the general maxim that war ipso facto abrogates treaties between the belligerents. But international jurists now place important limitations on this maxim. Its extent was much discussed in 1814, on the occurrence of the question, whether the rights of fishery accorded by Great Britain to the United States by former treaties were abrogated by the war of 1812: England maintaining the affirmative. It cannot be said that any satisfactory general view of the solution of this important problem has been arrived at. (Phillimore *On International Law*, part xii. ch. ii.)

Treaty, Commercial. The facts that particular counties are specially favoured in the growth or manufacture of special products, or are situated favourably for general commerce, or possess a natural control over certain districts from which articles of great importance or general demand are procurable, or are possessed of certain political, strategic, or similary important capacities, are reasons, early appreciated in political history, for diplomatic negotiation. The earliest treaty in existence, between Carthage and republican Rome, is quoted by Polybius, and is dated in the year which is assigned as the second after the expulsion of the Tarquins. It is almost entirely commercial in character. Commercial treaties are referred to by Aristotle (*Nicomachean Ethics* v. 5) as familiar facts. The exclusion of Megara from the markets of Athens and her dependencies, equivalent to a prohibition of nearly all foreign trade with Eastern Europe and Western Asia, was one of the grievances quoted as a plea for beginning the great Peloponnesian war. In point of fact, such formally enacted commercial regulations were inevitable in the singular interpolitical system which was so marked a feature in ancient Greece, while the motive was less prominent and operative under the absorbing military despotism of Rome.

The age of the Hanseatic League (about 1250) was the period in which such a system was renewed in Europe. This famous confederation, framed for the purpose of securing political and commercial liberty, by joint resistance to the outrages of feudal tyranny, was a great commercial treaty, in which the contracting parties bound themselves to common action, to a system of common defence, and common representation for the purposes of the league. The decline of this league began when the disorder, confusion, and rapine, which it was intended to prevent, were repressed by the agencies of a growing civilisation. With such a civilisation, grew also the conviction that the strength of a nation lay in the magnitude and security of its foreign commerce, and the view that the direction of this commerce was an important object in diplomacy.

Among European states, none appear to have acted with so much steady perseverance in the direction of what may be called commercial diplomacy as this country. It is not difficult to explain the reason, and (as economical enlightenment is comparative) to recognise the cause of the great prominence which this country assumed in the commerce of the western world five centuries ago, notwithstanding the caprice with which its acknow-

ledged policy was modified or suspended, or its progress thwarted by purely political intrigues. England at this time was well-nigh the sole producer of wool. The local police, all things considered, was excellent: property was sacred, and rapine rare. It may be that, at this period, sheep-farming for the purpose of wool was rare on the Continent; it is certain that it was full of risks, under the feudal anarchy which then impoverished Europe. It is impossible to keep sheep unless property is made safe by a vigorous executive; and there is abundant evidence that the peace was kept better in England than in any European community whose industry was specially agricultural—better perhaps than in any community whatever. But just opposite to the English coast and the best settled part of the country, were the factories of the Netherlands, the spinners and weavers of Liége, Ghent, and other towns. Between these regions and our country the most intimate commercial relations existed. The Flemings were invested with peculiar privileges, and invited to settle in England; and, by the close of the thirteenth century, so intimate were the relations between the two countries, that Norfolk, in which these Flemings had settled in great numbers, was by far the richest county in England, and was the seat of its most important manufactures.

The early French campaigns of our Edward III. were connected diplomatically with the commercial relations then existing between the Flemish weavers and the English wool staplers. The patriotism or the intrigues of Arteveldt, manifestly directed towards checking the feudal prerogatives of the counts of Flanders and the bishops of Liége, found an obvious and ready machinery in the mutual interests of the two countries. A century and a half after the events which preceded the battle of Crecy, those intrigues of Mary, duchess of Burgundy, which aimed at distressing Henry VII., the successful enemy of her house, were thwarted by the commercial treaty negotiated between the Flemish towns and the wily king of England, a treaty known for many a day afterwards by the name of the *Intercursus magnus*. During the wars of Henry V. and Henry VI. the dukes of Burgundy were attached to the English alliance quite as much on commercial grounds as they were stimulated by antipathy to the Armagnacs.

The acceptance of the mercantile system [POLITICAL ECONOMY], and the policy which followed its acceptance, bore the fullest fruits in the commercial treaties which were negotiated from the middle of the seventeenth century down to the middle of the nineteenth. The general purpose of these treaties was—to secure a market for our *exports*, and to admit reciprocally the exports of some nation with whom the treaty was concluded. Coupled with this arrangement, there was almost always some political alliance contemplated, some favour stipulated, which would never have been granted, except on the presumption that the admission of our exports was a great public advantage. The nation was taught that a less advantageous import trade was counterpoised by a more advantageous export trade; that the latter was an aid to capital, and an incentive to labour; that the principal object of trade was to export as much as possible; and that the grant of this kind of indirect bounty on home produce was an act of the highest political wisdom. It will not be difficult to show that it was an act of consummate folly.

It is of the greatest importance to a producer to know which is the market for which he produces, and he finds this out most surely by the freest intercourse of trade. Any guidance, any tutelage, any bounty—and a favoured market is a bounty—instead of aiding him in his interpretation of the market, bewilders and deludes him. The fact that his capital is diverted into such and such a channel by these indirect means, would be (from the general economical law, that the profits of equal capitals, other things being equal, are equal) no advantage to him; while the diversion of capital from more productive to less productive objects involves an inevitable loss to the aggregate capital of the community. The purport of the celebrated Methuen treaty, negotiated between England and Portugal in 1703, was the introduction of English woollens into Portugal. But the English woollen trade, during the greater part of the eighteenth century, was not in a healthy condition, and every kind of expedient was vainly attempted in order to stimulate and sustain it. Capital which might have been better employed was turned into a particular channel, and forced in an unnatural direction; and again, the general consumer, in order to secure these delusive advantages to the producer of some favoured article, is obliged, by way of compensation, to take certain goods which are dearer and less valuable than those with which an open market would have supplied him. Thus, in order to introduce woollens into Portugal, the English government agreed to tax all wines produced from other countries at the rate of one-third more than it taxed Portuguese wines. Such a proviso, as it excluded the most important, and up to the time at which the treaty in question was negotiated, the most familiar produce of France, naturally begot a policy of irritation, and, as a consequence, retaliatory restrictions. The trade between this country and France, which should have been large, was reduced to insignificance, and the two nations became estranged. In brief, no bargain could have been concluded on the basis of such commercial treaties as were in fashion up to within the last twenty years, without inflicting a double loss, one to capital, the other to consumption.

The excessive anxiety to stimulate exports is an economical error. A nation cannot, it is true, be indifferent to the restrictive or pro-

hibitive tariffs of other countries, since (even though, as is commonly the case, the tax levied in the country adopting such a protection or restriction may be paid by the consumers of such commodities as are imported legally, and a prohibition, if the article be in demand, will, even under circumstances very unfavourable for such transactions, be evaded by the practice of smuggling) such hindrances diminish demand, and render the interpretation of supply difficult. But the grant of facilities to imports is of much greater consequence. Every nation, however wedded to protective theories, desires to export; but unless it resolves on accumulating specie, and so raising prices by depreciating its currency, it must sell its exports for goods. So general is this desire to export, that governments rarely venture on export duties, and learn that they can fairly enough leave the exports to take care of themselves.

The system of the commercial treaties formerly negotiated has been exploded in this country, owing to the acceptance of free-trade principles. Treaties have been completed between this and other countries on a theory very different from that which sought to secure special favours for the trade of the contracting parties. The character of this later diplomacy may be best understood by taking a particular instance; for example, the treaty negotiated by the late Mr. Cobden between this country and France—a treaty the principle of which has been sometimes impugned by some who have considered that it involved a departure from free-trade principles, and by others who have thought that it tied the powers of the government in limiting the fiscal expedients of those which might be adopted. But neither of these charges was just.

Mr. Cobden, who was thoroughly acquainted with the nature of the trade between this country and France, and was alive to the excessive restraints which protectionist and retaliatory laws had put on the commercial intercourse between two countries which should enter into mutual relations to their manifest mutual advantage, suggested to Lord Palmerston and Mr. Gladstone, that, in his opinion, arrangements might be entered into, consequent on certain projected changes in the English tariff, which would partly increase the trade between the two countries. He did not suggest that any advantage should be given to France over other communities, but only that the alterations in our system—alterations which might very likely be made even if France were unwilling to negotiate—should, if possible, be turned to diplomatic account. It is clear that so long as any portion of the revenue of this country is derived from import duties, it will always be possible to adapt these duties to the interests of exporting countries, and therefore to make them a plea for fiscal concessions. We, it might be argued, adopt free trade as our rule; but we raise a revenue, partly from internal sources, partly from consumable articles of foreign growth. If no revenue were raised from these latter objects, we could not, it is true, do more than allege reasons in favour of our policy; as we do raise such a revenue, we are able, without departing from this policy in the least, to accommodate the method of this revenue to the exports of such countries as can supply us with what we need, but who will also meet us by relaxations in their fiscal methods. Such a proceeding is simply that of instructing a community that if they want to sell, they must buy; a position which may be manifest enough to some, but which is very slowly appreciated by such states as are devoted to protection. And although the negotiators of the treaty bound the nation to a certain course of procedure in future, the obligation was only not to do that which no government in this country would ever dream of proposing.

This mode of arranging the commercial relations of two countries has been ridiculed as a mere *missionary* act. But if diplomacy, while it abandons force, employs remonstrance, appeals strongly to mutual interests, attacks the arguments alleged in favour of an unsound policy, predicts the advantages of one course of action, and the evils of another, upon questions which are purely political, it is hard to say that similar representations should not be made when the matter in debate is simply commercial. Not, indeed, that intimate commercial relations are without a great political interest. The policy of insulation, of prohibition, of protection, is a war policy, full of danger and menace. But the more thoroughly the commerce of two countries is knit together, the more effectual are the guarantees of amity, good will, and peace, the more remote is the risk of quarrel. We cannot doubt that the anxiety which all political parties in this country feel for the preservation of peace, the determination which all evince to treat international questions with an increased regard to public law and morality, and to abstain as far as possible from menace or armed intervention, are due to the intimate commercial relations which have been established between this and other civilised communities. And if it be the case that extended commerce is a powerful pacificator, it is surely just, sound, and right that diplomatic action should be directed as far as possible to the developement of such causes as will lead to friendliness among nations, and to the reciprocity of advantages.

The commercial treaty with France has borne considerable fruits. The trade between the two countries has doubled since it was negotiated; and, far from depressing French goods, with which English products were to compete actively, the result has been that those fabrics and manufactures, of which the continued production, in the eyes of the French protectionists, would be imperilled by the treaty, have actually increased in greater ratio than even those commodities for which the treaty was previously intended to create a more abundant demand.

For the commercial treaties at present existing, and the effects which they produced on trade, see *Commercial Dictionary*, art. 'Treaty, Commercial.'

Treble (Fr. triple). In Music, the highest part in a concerted piece. Thus we say, a treble violin, a treble hautboy, &c. In vocal music, this part is sung by boys or females. The treble is divided into first or highest treble, and second or low treble.

Trebuchet (Fr.; Low Lat. trabutium). A warlike engine of the middle ages, used to throw stones, fiery material, and other projectiles employed in the attack and defence of fortified places by means of counterpoise. At the long end of a lever was fixed a sling to hold the projectile; at the short end a heavy weight, which furnished the necessary moving force. Experiments with engines of this nature were made by direction of the emperor Napoleon III., which are detailed in his *Etudes sur le Passé et l'Avenir de l'Artillerie.*

Treckschuyt (Dutch *track ship* or *boat*). The covered boats drawn by horses or cattle, and used for the conveyance of goods and passengers on the Dutch and Flemish canals, are so called. For an admirable description of the accommodations and management of the *treckschuyt*, now rapidly falling into disuse from the introduction of railways, see Murray's *Handbook for Northern Germany*.

Tree (A.-Sax. treo, perhaps akin to Gr. δρῦς, *a timber-tree*, especially *an oak*). Any woody plant of perennial duration, which rises from the ground with a trunk. To form a tree, the plant must acquire some considerable size, and be furnished with a trunk or single stem by which its branches or limbs may be supported. It differs from a shrub, which is a woody plant of smaller stature, in having a trunk; and it is the presence of this solid mass of wood which gives their especial utilitarian value to trees, furnishing, as many of them do, the timber which is applied to so many useful purposes.

Most of our hardy and indigenous trees are *deciduous*, i.e. they cast off their leaves in autumn, and their twigs and branches remain denuded till the following spring. To this class belong the well-known Oak, Ash, Elm, &c. Some trees, however, retain their clothing of foliage through the winter, and being at no time denuded, are called *evergreen*. To this group belong the Pine, Fir, Cedar, &c.

Trees may be, again, divided into *Ornamental Trees* and *Timber Trees*. The first of these groups is a numerous one, including subjects which afford great variety both of blossom and foliage, as the Tulip-tree, the Lime, the Horse-chestnut, some kinds of Oaks and Elms, the False Acacia, or Locust-tree, and many others. The second is also an extensive group, and may be subdivided into three: viz. coniferous or resinous trees; hard-wooded trees not resinous; and soft-wooded trees. Coniferous trees include many kinds of Pine and Fir, Larch, &c. The chief hard-wooded non-resinous trees are Oak, Chestnut, Ash, Elm, Beech, Horn-beam, Walnut, Sycamore, Locust, Birch, Apple, Pear, Cherry, Laburnum, Holly, and Yew. What are called soft-wooded trees comprise Lime, Horse-chestnut, Alder, and various Poplars and Willows.

Among the timber trees of tropical countries, the wood of which is imported for various uses, occur Mahogany, Rosewood, Teak, Sâl or Saul, Cedar, Ebony, Satinwood, the Gum-woods of Australia, African Oak, and many others. [ARBORICULTURE.]

Tree Fern. The name applied to those ferns which form erect trunks like the stem of a tree. They chiefly belong to the genera *Cyathea*, *Alsophila*, and *Dicksonia*.

Tree-hair. A name sometimes given to the dark wiry pendulous entangled masses of a lichen, *Cornicularia jubata*, which is not uncommon on trees in subalpine woods.

Tree-like. In Botany, this term is applied to plants which resemble a tree, but are very small. [DENDROID.]

Treenails. In Naval language, wooden bolts by which the planks of a ship's bottom are secured to the timbers.

Trefoil (Lat. trifolium, from tres, *three*, and folium, *a leaf*). In Architecture, an ornament of three cusps in a circle; resembling three-leaved clover.

TREFOIL. A name given in English to different kinds of three-leaved plants. White Trefoil is *Trifolium repens*; Yellow Trefoil is *Trifolium minus*; Black Trefoil is *Medicago lupulina*; Bird's-foot Trefoil, *Lotus corniculatus*. These plants are all used for the food of cattle. The French word *trèfle* has a similar application.

Tremando or **Tremolo** (Ital. *trembling*). In Music, a direction for one of the graces of harmony, which consists in a reiteration of one note of the chord: this, however, applies more directly to the word *tremolo*, whilst the *tremando* is a general shake of the whole chord.

Tremandraceæ (Tremandra, one of the genera). A small order of hypogynous Exogens, referred to the Sapindal alliance, and consisting of heath-like Australian shrubs, chiefly characterised by regular flowers, with four or five valvate sepals, as many spreading petals, twice as many free hypogynous stamens, anthers opening in terminal pores, and a free ovary, usually two-celled, with one, two, or rarely three pendulous ovules in each. The order, although small, is perfectly distinct in habit and character, having some affinity with *Polygalaceæ*, but is at once distinguished by its regular flowers.

Trematodes (Gr. τρηματώδης, from τρῆμα, *a hole*). The name of an order of Sterelminthans, or parenchymatous Entozoa, comprising those which have organs of imbibition and adhesion in the form of suckers.

Tremella (Lat. tremo, *I tremble*). A jelly-like plant of the lowest organisation, found in damp walks and similar situations. It is composed of a thallus containing microscopical

spores, and is closely allied to the plants called *lavers*.

Tremenheerite. An impure Indian Graphite, named after Major-General Tremenheere.

Tremolite. A variety of Hornblende, which occurs both crystallised and in slightly elastic fibres in the limestone of Glen Tilt, and in many parts of Scotland. It is a silicate of iron and magnesia, and is named after the Tremola Valley in Switzerland, the locality where it was originally found.

Trench Cart. In Artillery, a small cart, for single draught, used for transporting mortars and their beds, &c. in the trenches and elsewhere.

Trench Cavaliers. In the attack of a fortress, the high parapets of the single saps which are pushed along the slope of the glacis; they should be raised high enough to command the salient places of arms.

Trenches (Fr. tranchée). In the attack of a fortress, the approaches or excavations, made for the purpose of covering the advance of the besiegers. They are from six to ten feet wide, and about three feet deep, the earth taken out forming a parapet.

Trent, Council of. In Ecclesiastical History, a council assembled by Paul III. in 1545, and continued in twenty-five sessions, until 1563, under Julius III. and Pius IV. This celebrated council was convoked at a period when the Christian world was agitated by the early efforts of the reformers; and its most important decrees have therefore reference to the points on which the controversies of the Reformation chiefly turned: e.g. transubstantiation, image-worship, and the authority of the pope. The authority of these decrees (except so far as the more strictly doctrinal part of them is embodied in the creed of Pope Pius IV.) has been much debated among Romish ecclesiastics. In Germany, Poland, and Italy, they appear to have been adopted from the beginning without restriction; in Spain only with a reservation of the rights of the monarch; in France they have never been solemnly received. The more important portions of them, which contain the rule of faith, may be regarded as expressing the belief of the Roman Catholic church at the present day. The famous history of Paolo Sarpi is in many respects a noble work. That of Cardinal Pallavicino represents the view of the less moderate party among Roman Catholic theologians. (Mosheim, vol. iii.; Robertson's *Charles V.*; Hallam's *Introd. to the Literature of Europe*, vol. ii.; Ranke's *History of the Popes*.)

Trent Sand. [Rotten Stone.]

Trepan. A circular saw for perforating the skull. The term *trephine* is also applied to a similar but improved form of the instrument. (Cooper's *Surgical Dictionary*, art. 'Trephine.')

Trepang. [Holothuria.]

Trespass (Nor. Fr. trespasser, from Lat. trans, and passus, *a pace*). In Law, strictly any transgression of the law less than felony or misprision of felony; but the term is generally used to signify any wrong or damage done by one private person to another. *Trespass vi et armis* is where an act is done which is in itself an immediate injury to another's person or property; such as assault and battery, or breaking and entering a house or close. *Special trespass*, or *trespass on the case*, is where an act is not immediately injurious, but only by consequence and collaterally. Trespass is a personal action of tort, and lies for injuries of a very miscellaneous character.

Tressure. In Heraldry, a border running parallel with the sides of the escutcheon, which should contain about one quarter of the bordure. It is generally either double or triple, and has usually fleurs-de-lis, arranged in opposite directions alternately, perpendicular to the length of the tressure; it is then called *flory counter-flory*. The tressure forms part of the royal arms of Scotland, and of those of many noble Scottish houses.

Trestle (Fr. trêteau). A piece of timber supported at each end by legs. Two or more of them are used for carrying a bridge, called a *trestle bridge*.

Trestle-tree. Two bars of wood or iron at the mast-head, fitting on the shoulders of the mast, passing lengthwise of the ship, and holding up the cross-trees, on which and on the trestle-trees themselves the top is laid.

Tret (probably from Lat. tritus, part. of tero, Gr. τείρω, *I rub away*). In Commerce, an allowance of four pounds in every 104 lbs. for the waste which certain kinds of goods are liable to from dust, &c.

Trewiaceæ. An order formerly proposed by Lindley for the genus *Trewia*, which he has since, with other botanists, referred to *Euphorbiaceæ*.

Triad (Gr. τριάς, τριάδος). In Music, a compound of three sounds, which, being naturally divisible into two thirds (one major and the other minor, constituting a fifth in the whole), has received the name of the *harmonic triad*. Its name is founded on its being formed of a third and a fifth, which, with the bass or fundamental sound, make three different terms.

Triads. In Cymric Antiquities, the *Triads of the Welsh Bards* are poetical histories, in which the facts recorded are thrown into the form of triplets. Thus, to take the commencement of the first Triad as an example. 'Three names have been given to the Isles of Britain since the beginning: Clas Merddin, Til Inys, and Inys Pridain.' The Triads are supposed to be of no greater age than the reign of Edward I., although they probably contain fragments of old history. (Turner's *Anglo-Saxons*, vol. i.)

Trial. In Common Law, the examination and disposal of an issue or fact, either in criminal or civil proceedings. Trials are by *certificate*, by *inspection*, by the *record*, and *per pais*, i. e. a jury. The first three are of a pecu-

liar character. Trial by certificate is where the evidence of the person certifying is the only proper test of the issue; as, the customs of the city of London are to be tried by the *certificate* of the mayor and aldermen, &c. Trial by inspection is said to be where the judges personally examine and decide the question in dispute; a practice long obsolete. Trial by the record is where the point at issue being whether or not a certain record exists, or certain averments in it, it is decided by the production of the record itself. But the ordinary trial of all facts, with these very rare exceptions, is by a jury, summoned to try the issue raised by the pleadings. Trials at bar of civil actions are those which take place before all the judges of the court of which the record is; the original, and, as it were, direct mode of trial, from which all others are variations, although it is now very rare in practice. In ordinary cases, it has been long superseded by trial at Nisi Prius (since 13 Edw. I.). [Nisi Prius.] A trial at bar is now only granted on special grounds. These are the ordinary modes of disposing of issues raised on records in the superior courts; and trials of actions in courts of limited jurisdiction are governed by the same general rules. Criminal trials are had in like manner when an issue of fact (generally guilty or not guilty) is raised by the pleadings. *New trials*, in civil cases, are granted where the court sees reason to be dissatisfied with a verdict, on the ground that evidence was improperly received or rejected; or that the judge misdirected the jury as to the law applicable to the facts; or that the verdict was against the weight of evidence; or the damages exorbitant or insufficient; or that a party was unfairly surprised; or that fresh evidence has since been discovered; and in some similar cases.

Triamylamine. An organic base derived from ammonia by the replacement of three atoms of hydrogen in the latter by three of the radical amyl.

Triangle (Lat. triangulum). In Astronomy, one of the forty-eight constellations of Hipparchus, situated in the northern hemisphere. The same name is also given to one of the twelve southern constellations formed by Bayer. There is also the *Little Triangle*, added by Hevelius, near the first named. [Constellation.]

Triangle. In Geometry, a figure which has three sides, and consequently also three angles.

Triangles are *rectilineal*, *spherical*, or *curvilineal*. *Rectilineal* or *plane triangles* are bounded by straight lines; *spherical triangles* are formed on the surface of a sphere by the intersection of the planes of three great circles; *curvilineal triangles* are those which are bounded by three curves of any kind whatever.

Triangles receive other distinctive names from the relation of their sides and angles. A plane triangle is said to be *equilateral* when its three sides are all equal; *isosceles* when two only are equal; and *scalene* when all three are unequal. It is called *right-angled* when one of its angles is a right angle; *oblique-angled* when one of its angles is greater than a right angle; and *acute-angled* when each of its angles is less than a right angle; lastly, two triangles are said to be *similar* when their angles are respectively equal, each to each.

The following are some of the properties of plane triangles which it is useful to remember.

1. The greater side is opposite the greater angle, and vice versâ.

2. The sum of any two sides is greater, and the difference of any two sides less, than the third side.

3. The sum of the three angles is equal to two right angles; and if one of the sides be produced, the exterior angle is equal to the sum of the two interior and opposite angles.

4. The sum of the squares on two sides of a triangle is greater than, equal to, or less than, the square on the third side, accordingly as the angle enclosed by those sides is acute, right, or obtuse.

5. The perpendiculars erected at the middle points of the sides of a triangle meet in the centre C of the circumscribing circle. The lines joining the corners to the middle points of the opposite sides meet in the centre of gravity G. The perpendiculars let fall from the corners upon the opposite sides also meet in a point P, on the line CG produced through G so that $GP = 2GC$.

6. The six lines bisecting the interior and exterior angles of a triangle intersect in four points, which are the centres of the inscribed and the three escribed circles.

7. The middle points of the sides, and the feet of the perpendiculars let fall thereon from the angles respectively opposite thereto, all lie in the circumference of a circle which touches the inscribed and escribed circles. [Circle, Six-points.]

In general, a triangle is determined when three of its elements (sides and angles) are given. The exceptional cases are when the given elements are all angles, and when they consist of two sides and an angle opposite to the least of these sides. The latter is the *ambiguous case* of the *solution of triangles*. [Trigonometry.] The geometrical origin of the ambiguity is in the following proposition, which deserves a place in the elements of geometry.

8. If two triangles have an angle of the one equal to an angle of the other, and the sides about two other angles equal, each to each, the remaining angles will be either equal or supplemental.

Triangle. In Music, a small steel triangular musical instrument of percussion, open at one of its angles. It is set in vibration by being struck with a short metal bar.

Triangle, Arithmetical. The name given by Pascal to a table of certain numbers which are usually disposed in the form of a triangle. The first vertical column of the table

contains units only; the second contains the series of natural numbers; the third the series of triangular numbers; the fourth the series of pyramidal numbers; and so on. [FIGURATE NUMBERS.] Thus—

1						
1	1					
1	2	1				
1	3	3	1			
1	4	6	4	1		
1	5	10	10	5	1	
1	6	15	20	15	6	1
&c.	&c.	&c.	&c.	&c.	&c.	&c.

Any number in the table is obtained by adding the number next above it, in the same column, to the number in the same line in the next preceding column; and it will be observed that the oblique diagonal rows, beginning at the left and descending towards the right, are the same as the vertical columns. One of the properties of the table is, that numbers taken on the horizontal lines are the coefficients in the expansion of the different powers of a binomial. [BINOMIAL THEOREM.] For the description and uses of the table, see the Introduction to Hutton's *Mathematical Tables*.

Triangle of Forces. The name given to a theorem in Statics, according to which three forces which, applied to the same point, produce equilibrium are always parallel and proportional to the sides of a triangle, taken in order. The term *polygon of forces* is applied to the general theorem.

Triangle of Reference. Called also *fundamental triangle*. [CO-ORDINATES.]

Triangles, Conjugate. [CONJUGATE POINTS, LINES, AND TRIANGLES.]

Triangular Compasses. Compasses having three legs; two opening in the usual manner, and the third turning round an extension of the central pin of the other two, besides having a motion on the central joint of its own. The instrument is useful in the construction of maps and charts, as three points may be taken off at once.

Triangular Numbers. The series of numbers formed by the successive sums of the terms of an arithmetical progression, of which the common difference is 1. Thus:—

Arithmetical progression .	1, 2, 3, 4, 5, 6, &c.
Triangular numbers . . .	1, 3, 6, 10, 15, 21, &c.

The general term of the series is $\frac{1}{2}n(n+1)$. [FIGURATE NUMBERS.]

Triangulation. The cutting up of the surface of a country into a network of triangles with a view to the construction of a map. [SURVEYING.]

Triarii. The third, last, or veteran rank of infantry in the Roman legion. As these formed the last reserve, the phrase *rem ad triarios redisse* was used to signify that the last stake for victory had been thrown.

Trias. The Geological designation of the lowest and oldest of the secondary or mesozoic deposits. The name is derived from the division of the group into three parts, tolerably well marked on the continent of Europe; but in England the middle part is absent, and the separation between the upper and lower is thus rendered obscure. The rocks are usually known in England as the New Red Sandstone. Fossils are rare, but both plants and animals are indicated. The latter include some very remarkable and interesting reptilian forms. [BUNTER SANDSTEIN; DESCRIPTIVE GEOLOGY; KEUPER; MUSCHELKALK; NEW RED SANDSTONE.]

Tribasic Acids. When an acid, on being brought in contact with a metallic oxide, exchanges three atoms of hydrogen for an equivalent amount of metal, it is termed a *tribasic acid*.

Tribe (Lat. tribus, perhaps akin to tres, and the Sanscrit root bhu, *to be*, and hence to the Æolic τριττὺς = τριττύς, *a third part*). A principal subdivision of the Roman people; but of the origin and nature of this classification little is known with certainty. According to Dionysius, ROMULUS divided the people into three tribes, and each tribe into thirty curiæ. Livy in one place (i. 13, 36) speaks of the RAMNENSES, Titienses, and Luceres, as forming the three centuries of knights; in another (6) he mentions them as the three ancient tribes. SERVIUS TULLIUS is said to have divided the city, as enlarged by himself, into four local tribes, in place of the three hereditary tribes, hitherto existing, the country being divided by him into twenty-six tribes according to Fabius, or thirty-one according to Vennonius. Ten of these tribes are supposed by Niebuhr to have been swept away by the cession of the territory on the Etruscan bank of the Tiber to Porsena, as twenty-one tribes are mentioned by Livy shortly after the battle of Regillus; but Livy mentions only the four city tribes in the reign of Servius, and we do not know what he supposed the whole number to have been. Sir G. C. Lewis adds that Livy's words 'imply that the number of twenty-one for the tribes was voluntarily established in the year 496 B.C. after the battle of Regillus, and without any reference to the war of Porsena.' The futility of Niebuhr's explanation is, in Sir G. C. Lewis's judgment, proved by the fact that, according to Livy, the number of twenty-one tribes remained unchanged for more than a century, whereas the effects of Porsena's war were, according to Niebuhr's own view, soon obliterated; and if the number was diminished on account of loss of territory, it is reasonable to suppose that it would have been increased to its former complement as soon as the territory was recovered. (*Credibility of Early Roman History*, ch. xii. sec. 13.)

But the division of nations or peoples into tribes may be regarded as having been universal, the number of the tribes varying from three, as in some Greek peoples, to twelve, as with the Hebrews. This division, like that of the Celtic clans, was based essentially on a religious foundation, each tribe having its common sacrifices and festivals; and these tribes,

standing on an equality with each other, must be carefully distinguished from the populations which were held in subjection. Thus, the Thessalians had their PENESTÆ, the Spartans their HELOTS; but neither Penests nor Helots were included in the tribal divisions of their conquerors. The Dorians, called in the *Odyssey* Τριχάϊκες, or the people of three tribes, were subdivided originally into the Hyllæans (said to be named from Hyllus, a son of HERACLES), the Dymanatæ, and the Pamphyli, the last named furnishing a parallel to that of the Panhellenes. To these three tribes, others were from time to time added in different places. Thus, eight tribes are mentioned in Corinth, and four in Tegea. The twelve tribes of Elis, reduced to eight by a war with the Arcadians, seem to have been geographical divisions. The Ionian division appears to have been fourfold. Those of Attica, which, according to some traditions, had borne other names, were the Geleontes, the Hoplites, the Argades, and the Ægicoreis. The origin of these names can be accounted for only by conjecture, and the last three are explained etymologically as representing, respectively, the armed men or warriors, the husbandmen, and the goatherds. Of the term Geleontes, no interpretation can be given, and it has been supposed that their name was really Teleontes, and that it had reference either to sacerdotal duties, and thus denoted the priestly caste, or to a payment of rent, and thus denoted the peasantry. Against the former notion, it is urged that Athenian history gives no sign of the existence of any priestly caste, and against the latter that the Teleontes would thus be identified with the Argades. THESEUS, it is said, introduced a new division into Eupatridæ (or nobles), Geomori (or agriculturists), and Demiurgi (or artisans); but the relation of these classes with the tribes has not been precisely ascertained.

Tribometer (Gr. τρίβω, *I rub*, and μέτρον, *measure*). In Mechanics, the name given by Musschenbroek and Coulomb to a sort of sledge or apparatus for measuring the force of friction. [FRICTION.]

Tribromaniline. Aniline in which three atoms of the hydrogen have been replaced by three of bromine.

Tribunal (Lat.). In Roman Antiquities, a raised platform on which the prætor and judices sat in the Basilica.

The tribunal in the camp was formed either of turf or of stone, and from it the general addressed his soldiers, and the council and tribunes administered justice.

Tribune. Properly, as the name denotes, the chief magistrate of a *tribe*. There were several kinds of officers in the Roman state who bore the title. 1. The plebeian tribunes, who are said to have been first created after the secession of the commonalty to the Mons Sacer (260 A.U.), as one of the conditions of its return to the city. They were especially the magistrates and protectors of the commonalty, and no patrician could be elected to the office. At their first appointment the power of the tribunes was very small, being confined to the assembling the plebeians and to the protection of any individual from patrician aggression; but their persons were sacred and inviolable, and this privilege consolidated their other powers, which were finally incorporated with the functions of the other chief magistracies in the person of the emperor. The number of the tribunes varied from two to ten, and each of these might annul the proceedings of the rest by putting in his veto. (Niebuhr's *Hist. of Rome*, 2nd edit. i. 624; Lableterie, *Mém. de l'Acad. des Inscr.* vol. xxxvii.) 2. Military tribunes, said to have been first elected in the year 310 A.U. in the place of the consuls, in consequence of the demands of the commonalty to be admitted to a share of the supreme power. The number of the military tribunes is represented as sometimes six and sometimes three. For above seventy years, we are told, sometimes consuls were elected and sometimes military tribunes; at last the old order was permanently restored, but the plebeians were admitted to a share of it. (*Mém. de l'Acad. des Inscr.* vol. xxxvii.) 3. Legionary tribunes, or tribunes of the soldiers, were the chief officers of a legion, six in number, who commanded under the consul, each in his turn, usually about a month: in battle each led a cohort.

For the difficulties and contradictions which run through the narratives of the institution of plebeian and military tribunes, see Sir G. C. Lewis, *Credibility of Early Roman History*.

TRIBUNE (Fr.). In Modern Political History, the elevated kind of pulpit occupied by members of the French assemblies in order to make a speech; hence, the eloquence *of the tribunes*, in the sense of parliamentary eloquence.

Tribute (Lat. tributum). A sum of money paid by an inferior sovereign or state to a superior potentate, to secure the friendship or protection of the latter. The *black mail*, formerly levied by the Scottish borderers on their less powerful neighbours, for protecting their property from the depredations of caterans, was a species of tribute.

In Roman History, the tributum was a tax on real property, which, according to Niebuhr, was at first paid only by plebeians, the name being used in connection with the Servian tribes. Livy, however, states (iv. 60) that it was also paid by patricians. The usual amount was one for every thousand of a man's fortune, though in the time of Cato it was raised to three in a thousand. Its oppressiveness was caused chiefly by its constant fluctuation.

Trica. In Botany, one of the names of the shield or reproductive organ of a lichen.

Trichechus (Gr. θρίξ, *hair*, and ἰχθύς, *fish*). A name invented by Artedi to designate the manatee, as being the only species of fish, or whale-fish, that was hairy: 'quia solus inter pisces fere hirsutus sit.' Linnæus, in his *System of Nature*, adopted the term *trichechus* as the generic appellation for the manatee (*Trichechus manatus*); but he added the walrus

as a second species of the genus. Subsequent zoologists, in separating these very different animals, and placing them in distinct genera, have in this, as unfortunately in too many other cases, invented a new generic name for the animal so well designated by its original epithet, and have restricted the application of the term *trichechus* to the walrus, for which it was not originally designed.

Trichiasis (Gr. τριχίασις). A disease of the eyelids, in which the eyelashes grow inwards and irritate the bulb of the eye.

Trichidium (Gr. θρίξ). In Botany, a netted filamentous organ resembling a netted purse, in which the spores of some kinds of fungi are included.

Trichilia (Gr. τρίχα, *in three parts*). A genus of *Meliaceæ*, restricted to two or three African, and about a dozen American and West Indian species, some of which are trees, and others erect or climbing shrubs with unequally pinnate or trifoliate leaves and axillary panicles of flowers. *T. emetica*, the Roka of the Arabs, is a large tree, with pinnate leaves, and dense panicles of whitish flowers, like those of the citron. The fruits are said to possess emetic properties. The Arabian women mix them with the perfumes used for washing their hair; while the ripe seeds are made into an ointment with sesamum-oil, and used as a remedy for the itch.

Trichina (Gr. θρίξ, *a hair*). A genus of minute nematoid worms, infesting, in the adult procreative state, the intestinal canal, and, in its larval state, the muscular tissue of man and certain mammals, especially the hog. It is probable that the minute bodies in the muscles of the dropsical drunkard, described by Tiedemann, and analysed by Gmelin as *arthritic concretions* (Froriep's *Notizen*, bd. i. s. 64, 1821), were old calcified cysts of *Trichina*: it is certain that the minute bodies in human muscles, described as *Cysticerci* by Hilton (*Medical Gazette*, February 2, 1833, p. 605), were the adventitious cysts of *Trichina*. The discovery of the worm itself within the cyst, and of the true or adventitious nature of the latter, was made by Owen in 1835, and the worm was described and named by him *Trichina spiralis*, from its common disposition in the cyst, in the *Transactions of the Zoological Society of London*, vol. i. p. 315. Herbst (*Nachrichten von d. G. A. Universität und der K. Gesellschaft d. Wissenschaften*, 1851, No. 19) first showed that the encysted spiral *Trichinæ* were immature, the young of adult *Trichinæ* liberated and fully developed in the intestines of animals which had eaten meat containing encysted *Trichinæ*.

Virchow (*Archiv* 1860) repeated and confirmed Herbst's experiments, and describes the mature *Trichinæ* of both sexes. These acquire the procreative state on the second day after the trichinous meat has been taken into the stomach. About the sixth day the minute filaria-like embryos hatched within the oviducts of the female are excluded. They forthwith penetrate the mucous coat or walls of the intestine, enter the capillaries, are transported by the circulation to the whole muscular system, pierce and escape from the capillaries to penetrate that tissue, and within a fortnight attain the ordinary characters of *Trichina spiralis*, providing themselves by irritation of the sarcolemma with their adventitious cyst, which, at a later period, may become calcified.

As the first introduction of *Trichina* is from eating meat, the animal matter in the garbage or offal commonly given to pigs occasions the frequency of their occurrence in that domestic animal.

Where the custom may prevail of eating pork, or particular forms of pork, e.g. ham, bacon, sausages, &c., imperfectly cooked or raw, the *Trichinæ* in such meat are introduced in a state highly favourable for their developement and procreation into the intestine, and thus is produced the painful and often fatal disease called *Trichiniasis*. The symptoms and cause of this disease are described by Rupprecht, in the notable epidemic degree of the disease, which occurred at Hettstadt, in 1863, and in Dr. Thudicum's excellent report, 'On the Parasitic Diseases of Quadrupeds used for Food.' (No. 7, *Medical Department of the Privy Council*, 1865.) Wholesome feeding of the pig with vegetable food, and thorough cooking of the pork, are the main preventives of *Trichiniasis*.

Trichina Spiralis. [TRICHINA.]

Trichiurus (Gr. θρίξ, and οὐρά, *a tail*). The name of a genus of spiny-finned fishes, literally rendered in their popular English name of *hair tails*, in reference to their most striking generic character, which is taken from the single elongated hair-like filament terminating the rayless tail. The *Trichiuri* have no anal fin, and have neither ventral fins nor supplemental scales. But one species, viz. the silvery hairtail (*Trichiurus lepturus*, Linn.), has been admitted into the catalogue of British fishes.

Trichloracetic Acid. Acetic acid in which three atoms of hydrogen have been replaced by three of chlorine.

Trichlorokinone. A chlorinated derivative of Kinone.

Trichocephalus (Gr. θρίξ, and κεφαλή, *a head*). The name of a genus of Nematoid Entozoons, one species of which (*Trichocephalus dispar*, Rudolphi) infests the human intestinum cæcum.

Trichopterans (Gr. θρίξ, and πτερόν, *a wing*). The name of an order of insects founded by Kirby for the case-worm flies, which are characterised by four hairy membranous wings, resembling in their nervures those of the Lepidopterans; the under ones folding longitudinally.

Trichosanthes (Gr. θρίξ, and ἄνθος, *a flower*). A genus of *Cucurbitaceæ*, consisting chiefly of Asiatic species, which are trailing or climbing plants, with heart-shaped, entire, or lobed leaves, and flowers of separate sexes, usually borne on the same plant. *T. cucumerina*, the Doommaala, a common Cingalese and South Indian plant, is much valued by the native doctors in Ceylon as a remedy for

fevers; and experiments show that it possesses considerable efficacy. It contains tannic acid; and the infusion of it, which is the form used, is very bitter. The Central American *T. colubrina*, the Serpent Cucumber or Viper Gourd, is so called from the remarkable snake-like appearance of its fruits, which are frequently six feet long or more, and at first striped with different shades of green, but ultimately changing to bright orange. *T. anguina*, another long-fruited species, a native of India and China, is called the Snake Gourd.

Triclasite (a word coined from Gr. τρίς, *thrice*, and κλάσις, *cleavage*). A Mineralogical synonym of FAHLUNITE, having reference to its threefold cleavage.

Triclinium (Lat.; Gr. τρίκλινος, *with three couches*). In Ancient Architecture, a room for the entertainment of guests, furnished on three sides with couches, the fourth side being left open for the attendance of the servants. The winter triclinia were placed to the west, and those for summer to the east.

Tricoccæ (Gr. τρίκοκκος, *with three grains*). A name under which Klotzsch and some others have designated the large order *Euphorbiaceæ*, taken in its most enlarged sense.

Tricoccus (Gr. τρίκοκκος). In Botany, a fruit consisting of three cocci, or seeds with elastically dehiscing shells.

Tricolor. The national French banner of three colours, blue, white, and red, adopted on the occasion of the first revolution. The immediate reason for assuming them is said to have been that they were the colours worn by the servants of the duke of Orleans; and they were first borne by the people when the minister Necker was dismissed in 1789. But these colours, in combination, appear to have formed a national emblem in France from a very early period. It is also said to have been formed by uniting the three colours successively used in the French standards at different periods; viz. the blue of the banner of St Martin, the red of the oriflamme [ORIFLAMME], and the white of the white cross, supposed to have been assumed under Philip of Valois. The three colours were given by Henry IV. to the Dutch on their desiring him to confer on them the national colours of his country; and they have since been borne successively by the Dutch republic and the kingdom of the Netherlands. The domestic livery of Louis XIV. was tricoloured, as were also the liveries of the Bourbon kings in Spain. At the revolution, when the three colours were assumed on the national flag, they were borne in the same order as the Dutch, but in a different position, viz. the division of colours parallel to the flagstaff, whereas in the Dutch flag it is at right angles with it. Besides being the favourite banner of the French, tricoloured flags have been adopted in Belgium, Germany, Italy, &c.

Triconodon (Gr. τρεῖς, *three*; κῶνος, *cone*; and ὀδούς, *tooth*). The *Triconodon mordax* was a small carnivorous marsupial animal, of which the crowns of the molar teeth of the lower jaw consisted of three nearly equal cones on the same longitudinal row, the middle one being scarcely larger than the front and hind cone; the coronoid process was larger in proportion to the entire jaw, and afforded a more extensive surface of attachment to the principal biting muscles than in most predatory extinct or recent quadrupeds. It has been found in the Purbeck strata with *Spalacotherium*.

Tricuspid Valve. The valve of the right ventricle of the heart.

Trident (Lat. tridens). The three-pronged sceptre which the poets and painters of antiquity placed in the hand of NEPTUNE is so called by way of eminence.

Triennial Act. The stat. 6 & 7 Wm. & Mary c. 2; providing that a parliament should be held once in three years at least, and that no parliament should last longer than three years. By the Septennial Act (1 Geo. I. sess. 2, c. 38), the duration of parliament was prolonged to seven years.

Triens (Lat.). A small Roman copper coin, worth one-third of the As, as the word implies. This was the piece of money usually placed in the hands of the deceased poor to pay Charon for their passage over the Styx.

Trierarchia (Gr. τριηραρχία). An Athenian institution which imposed on a certain body of citizens the duty of fitting out triremes for the use of the state. About 1,200 citizens were usually chosen for this purpose from the richest individuals, and these were subdivided into clubs of 12 or 16 to each ship. Demosthenes introduced a new regulation, by which the burden to be borne by each individual was made to bear a given proportion to his property. This was effected by making 1,200 of the wealthiest citizens συντελεῖς or partners, and dividing these into twenty Συμμορίαι, or classes, out of which a number of persons joined for the maintenance and management of a ship, under the title of a συντέλεια or union, these synteleiæ consisting generally of 15 persons. [LITURGY.] (Boeckh, *Public Economy of Athens*, ii. 319, 360.)

Trieteris (Gr. τριετηρίς). In Grecian Chronology, a cycle said to have been invented by Thales to correct his year, which consisted of 12 months of 30 days each, amounting to 360 days; as this fell short of the true solar year, he inserted a month of 30 days at the end of every three years, by which means he made it exceed the true year by 13 days.

Triethylamine. A powerful volatile organic base derived from ammonia by replacing the whole of the hydrogen in the latter by ethyl.

Triethylphosphine. An organic base resembling triethylamine, but containing phosphorus in place of nitrogen. It stands to phosphuretted hydrogen in the relation of triethylamine to ammonia.

Trifoliate or **Trifoliolate** (Lat. trifolium, *trefoil*). In Botany, terms applied to leaves which bear three leaflets from the same point, as in those of the clover.

Trifolium (Lat. tres, *three*, and folium, *a leaf*). A genus of papilionaceous *Leguminosæ*, distinguished by their trifoliate leaves, with stipules adhering to the leaf-stalk, and commonly known as Clovers or Trefoils. There are numerous species, several of them natives of Britain, and some of them important from an agricultural point of view. Of these the following may be mentioned: *T. pratense*, the Broad-leaved Red Clover, is extensively employed as a shifting crop, either by itself, or in mixtures which the farmer calls *seeds*. Its arable form is much larger than the wilder varieties, the former being so much an induced plant that it has become difficult to make it hold to some lands so perfectly as it formerly did, in which cases the soil is described as clover sick. *T. medium*, the Zigzag Clover, is a lover of sandy soils, whereas the *T. pratense* is not so well adapted for light land; and being a large species it appears to have been introduced to cultivation as a good cropper where the commoner clover had failed. Its place is now generally supplied by *T. pratense perenne*, commonly called Cow-grass. *T. incarnatum*, the Carnation Clover, is an annual species, much used (especially in the early soils in the neighbourhood of London) upon the white-crop stubble sown in autumn. Several varieties of its seed can be obtained. *T. hybridum*, the Alsike Clover, is much grown on the Continent. It has got the name of *hybrid clover* from its apparently possessing characters intermediate between the common red and Dutch clovers. It is a good pasture plant, its shoots trailing along the ground without rooting, as do those of the Dutch trefoil. *T. repens*, the Dutch clover or shamrock of Ireland, is a valuable feeding plant in dry and thin soils; and in laying down permanent pastures, unless in strong land, it should be always pretty freely employed. Its spontaneous growth in the meadow is always hailed as a sign of an improved condition. A four-leaved shamrock is esteemed by superstitious persons as being lucky, perhaps upon the principle that it is thought to be fortunate to get anything rare; but in truth, four-leaved and even-leaved clovers are not unfrequently met with.

Triforium (Lat.). In Gothic Architecture, an arched story between the pier arches and the clere-story of a building.

Trigamous (Gr. τρεῖς; γάμος, *marriage*). In Botany, a term sometimes applied to plants containing three sorts of flowers in the same flower-head; i.e. males, females, and hermaphrodites.

Trigeminus (Lat.). The fifth pair of nerves; they arise from the side of the pons varolii, where its fibres are prolonged into the middle crura of the cerebellum, and are divided within the cranium into three branches; viz. the *orbital*, and the *superior* and *inferior maxillary*. The orbital branch is divided into the *frontal, lacrymal*, and *nasal nerves*; the inferior maxillary into the *spheno-palatine, posterior alveolar*, and *infraorbital nerves*; and the inferior maxillary into two branches, the *internal lingual*, and one more appropriately termed the *infra-maxillary*. The trigeminal nerve consists of a ganglionic and a non-ganglionic portion.

Trigenic Acid. A crystalline derivative of aldehyd obtained by the action of cyanic acid upon the latter substance.

Trigger (Dan. trekker, Welsh trigaw, akin to Lat. traho, *to draw*). A catch which, being pulled, disengages the hammer of a gun-lock, that it may ignite the percussion arrangement. A hair trigger is one which, when set, will disengage the hammer by the slightest touch, whereas the common trigger requires a pull of some force.

TRIGGER. A small wedge placed under the foot of the dogshore, and suddenly withdrawn at the moment of launching a ship.

Triglyph (Gr. τρίγλυφος, *thrice cloven*). In Architecture, an ornament in the Doric frieze consisting of two whole and two half channels separated by flat spaces called *femora*

Trigonals (Gr. τρίγωνος, *three-cornered*). The name of a family of Decapodous Crustaceans, the carapace of which is nearly triangular.

Trigonella. The most remarkable species of this genus of *Leguminosæ* is that called *T. Fœnum græcum*, the Fenugreek, an erect annual plant, a native of the Mediterranean region, cultivated in India and other warm countries, and occasionally seen in England, though our climate is scarcely suitable to it. The seeds of Fenugreek were held in high repute among the ancient Egyptians, Greeks, and Romans, for medicinal and culinary purposes, but at the present day their use in medicine is with us confined to veterinary practice—Fenugreek powder being the principal ingredient in most of the quack nostrums which find so much favour amongst ignorant grooms and horse-keepers. The seeds have a powerful odour of *coumarine*, and are now largely used for flavouring the so-called concentrated cattle-foods, and for rendering damaged hay palatable.

Trigonia (Gr. τρίγωνος). A name applied by Lamarck to a genus of Ostracean Bivalves, most of the species of which are found fossil, but which has a beautiful representative in the seas of the southern hemisphere, remarkable for the iridescent lining of the valves, *La Trigo nacrée* of Lamarck. It is also the name of a genus of South American plants.

Trigoniaceæ. The genus *Trigonia*, consisting of tropical American trees, with opposite stipulate leaves, and paniculate flowers, presents so many anomalies, that it has been proposed to consider it as a distinct order of polypetalous dicotyledons under the name of *Trigoniaceæ*. It had been referred to *Polygalaceæ*, chiefly on account of its irregular flowers and the long hairs of its seeds; but it has little else in common with the plants of that order, and the position of the petals and insertion of the stamens is quite different.

Trigonocephalus (Gr. τρίγωνος, and κεφαλή, *a head*). A genus of poisonous serpents,

characterised by having the tail terminated by a horny conical process or spur. No species is known to inhabit Europe or Africa, in which continents the *Trigonocephali* are replaced by the vipers. The poisonous serpent of the island of Martinique, called by the French settlers *fer de lance*, is a species of the present genus (*Trigonocephalus lanceolatus*).

Trigonometry (Gr. τρίγωνος; μέτρον, *measure*). This term, as its derivation implies, originally signified the measurement of triangles. In its modern acceptation, however, it denotes that branch of mathematics which treats of angles and of certain ratios connected therewith. Trigonometry is of primary importance in mathematics, and is treated in all text-books: we shall limit ourselves here to a few definitions and formulæ.

Referring to the articles ANGLE and CIRCULAR MEASURE for the methods of estimating the magnitudes of angles, we may proceed at once to the consideration of the four *trigonometrical ratios* or *functions* of an angle known as *sine*, *tangent*, *secant*, and *versed sine*, abbreviations for which are *sin.*, *tan.*, *sec.*, and *versin.*, and to the corresponding functions of the complementary angle, known as *cosine*, *cotangent*, *cosecant*, and *coversed sine*, and usually written *cos.*, *cot.*, *cosec.*, and *coversin*. It would be sufficient to give the *geometrical* definition of one of these eight functions, and define the rest by means of it: we will, however, select two, the *sine* and *cosine*, for this purpose.

The perpendicular divided by the hypothenuse of a right-angled triangle is the *sine* of the angle between the hypothenuse and the base; the base divided by the hypothenuse is the *cosine* of the same angle. By the properties of similar triangles, it is manifest that the ratios thus defined do not depend upon the magnitude of the triangle; in other words, it does not matter from what point of one side (the final line) of an angle we let fall a perpendicular upon the other side (initial line). When the angle is acute, the above definitions of sine and cosine are complete and simple; to extend them to angles of all magnitudes, we notice that, in the language of co-ordinate geometry, the base, perpendicular, and hypothenuse, above mentioned, are, respectively, the *abscissa*, the *ordinate* and the *radius vector* of a point in the final line of the angle. Now, if the radius vector be considered as a *signless* line, whilst the abscissa and ordinate of its extremity follow the ordinary rule of signs [CO-ORDINATES], we have, generally,

$$sine = \frac{ordinate}{rad.\ vector},\quad cosine = \frac{abscissa}{rad.\ vector}.$$

The sine and cosine of an angle are manifestly *periodical functions*, i. e. as the angle increases, the same values recur after every complete rotation. Thus, in the first four quarter rotations, the sines have the signs +, +, −, −, and the cosines the signs +, −, −, +; the first passes through the values 0, 1, 0, −1; the second through the values 1, 0, −1, 0, and all intermediate values. The remaining six trigonometrical functions are defined by the equations—

$$\tan\theta=\frac{\sin\theta}{\cos\theta},\ \sec\theta=\frac{1}{\cos\theta},\ \text{versin}\,\theta=1-\cos\theta,$$

$$\cot\theta=\frac{\cos\theta}{\sin\theta},\ \text{cosec}\,\theta=\frac{1}{\sin\theta},$$

$$\text{coversin}\,\theta=1-\sin\theta,$$

from which their changes of value and sign may be easily traced. The theorem of Pythagoras, in virtue of which $(\text{ordinate})^2+(\text{abscissa})^2=(\text{rad. vector})^2$ leads at once to the formula $\cos^2\theta+\sin^2\theta=1$, which is true for all values of θ, and from which are at once deduced the formulæ—

$$1+\tan^2\theta=\sec^2\theta,\text{ and }1+\cot^2\theta=\text{cosec}^2\theta.$$

Again, the theory of projections leads at once to the *fundamental formulæ*—

$$\sin(\theta+\phi)=\sin\theta\cos\phi+\cos\theta\sin\phi,$$
$$\sin(\theta-\phi)=\sin\theta\cos\phi-\cos\theta\sin\phi,$$
$$\cos(\theta+\phi)=\cos\theta\cos\phi-\sin\theta\sin\phi,$$
$$\cos(\theta-\phi)=\cos\theta\cos\phi+\sin\theta\sin\phi;$$

which are likewise true for all values of θ and ϕ, and from which numerous other formulæ are deducible. Thus we have

$$\tan(\theta\pm\phi)=\frac{\tan\theta\pm\tan\phi}{1\mp\tan\theta\tan\phi},$$
$$\tan 2\theta=\frac{2\tan\theta}{1-\tan^2\theta},$$
$$\sin 2\theta=2\sin\theta\cos\theta,$$
$$\cos 2\theta=\cos^2\theta-\sin^2\theta$$
$$\sin A+\sin B=2\sin\frac{A+B}{2}\cos\frac{A-B}{2}.$$
$$\sin A-\sin B=2\cos\frac{A+B}{2}\sin\frac{A-B}{2}$$
$$\cos A+\cos B=2\cos\frac{A+B}{2}\cos\frac{A-B}{2}$$
$$\cos A-\cos B=-2\sin\frac{A+B}{2}\sin\frac{A-B}{2}.$$

By means of DE MOIVRE'S THEOREM, other important formulæ are deducible. Thus, if n denote any positive integer, the following series will terminate and give the values of the sine and cosine of a multiple angle $n\theta$, in terms of powers of the sine and cosine of the simple angle θ.

$$\sin n\theta=n\cos^{n-1}\theta\sin\theta$$
$$-\frac{n(n-1)(n-2)}{1\,.\,2\,.\,3}\cos^{n-3}\theta\sin^3\theta$$
$$+\frac{n(n-1)(n-2)(n-3)(n-4)}{1\,.\,2\,.\,3\,.\,4\,.\,5}\cos^{n-5}\theta\sin^5\theta-\&c.$$

$$\cos n\theta=\cos^n\theta-\frac{n(n-1)}{1\,.\,2}\cos^{n-2}\theta\sin^2\theta$$
$$+\frac{n(n-1)(n-2)(n-3)}{1\,.\,2\,.\,3\,.\,4}\cos^{n-4}\theta\sin^4\theta-\&c.$$

From these, again, and by aid of an easily demonstrated theorem which shows that $\frac{\sin\theta}{\theta}$,

where θ is the circular measure of a small angle, approaches the limit 1 as θ diminishes without limit, the following series are deduced:—

$$\sin\theta = \theta - \frac{\theta^3}{\lfloor 3} + \frac{\theta^5}{\lfloor 5} - \frac{\theta^7}{\lfloor 7} + \&c.$$

$$\cos\theta = 1 - \frac{\theta^2}{\lfloor 2} + \frac{\theta^4}{\lfloor 4} - \frac{\theta^6}{\lfloor 6} + \&c.$$

and these, when compared with the Exponential Theorem, lead to the important and remarkable relations:—

$$\sin\theta = \frac{e^{\theta\sqrt{-1}} - e^{-\theta\sqrt{-1}}}{2\sqrt{-1}}$$

$$\cos\theta = \frac{e^{\theta\sqrt{-1}} + e^{\theta\sqrt{-1}}}{2}.$$

With respect to the primary problem of trigonometry, the *solution of plane triangles* or the determination of three unknown elements (sides or angles) from three known ones, we remark merely that the definitions of the trigonometrical functions lead at once to the solution of all cases of right-angled triangles, whenever, by means of *trigonometrical tables*, the angles corresponding to given values of trigonometrical functions, and, conversely, the values of the several trigonometrical functions corresponding to given angles, can be found.

The several cases of oblique-angled triangles are easily solved by means of the following relations: If a, b, c, represent the sides of a triangle respectively opposite to the angles A, B, C, and for brevity we put $2s = a + b + c$, then $\frac{\sin\theta}{a} = \frac{\sin B}{b} = \frac{\sin C}{c} = \frac{2\,\Delta}{a\,b\,c}$; where Δ, the *area of the triangle*, has the value

$$\Delta = \sqrt{s\,(s-a)\,(s-b)\,(s-c)}.$$

When two sides a, b, and the included angle C are given, the third side may be found by the formula $c^2 = a^2 + b^2 - 2\,a\,b\cos C$, immediately deducible from Euclid ii. 12, 13. The angles A and B may be found, without calculating c, from the formula—

$$\frac{\sin A - \sin B}{\sin A + \sin B} = \frac{a-b}{a+b} = \frac{\tan\frac{A-B}{2}}{\tan\frac{A+B}{2}},$$

since $\frac{A+B}{2} = \frac{\pi - C}{2}$ is known. When two sides a, b, and a *non-included* angle B are given, the formula $\sin A = \frac{a}{b}\sin B$ will lead at once to the discovery of A, provided we know that A is less than B, which will be the case if a is less than b. If a be greater than b, however, then since an angle and its supplement have the same sine, we cannot decide which to select of the two angles given by the above formula for A. This is the so-called *ambiguous case*. [Triangle.]

We proceed with equal brevity to notice *Spherical Trigonometry*, or that branch of trigonometry which treats of the relations existing between the sides and angles of spherical triangles. Referring to the article Spherics for the necessary definitions, we may remark that all spherical trigonometry is comprehended in the formula—

$$\cos a = \cos b\cos c + \sin b\sin c\cos A,$$

where a, b, c represent the *sides* of the triangle, i. e. the *angles* subtended at the centre of the sphere by the arcs of great circles which form the sides, and A, B, C, the *angles* respectively opposite to a, b, c. It is obvious that in the above formula, as in all the following, we may obtain others by mere permutations of letters. Introducing the symbol s to denote half the sum of the sides, we readily deduce from the above formula the following two:—

$$\sin^2\frac{A}{2} = \frac{\sin(s-b)\sin(s-c)}{\sin b\sin c},$$

$$\cos^2\frac{A}{2} = \frac{\sin s\sin(s-a)}{\sin b\sin c};$$

whence, by division, we obtain the value of $\tan\frac{A}{2}$, and by multiplication the following:—

$$\frac{\sin A}{\sin a} = \frac{2\,\{\sin s\sin(s-a)\sin(s-b)\sin(s-c)\}^{\frac{1}{2}}}{\sin a\sin b\sin c}$$

From the symmetry of the expression on the right, we at once conclude that

$$\frac{\sin A}{\sin a} = \frac{\sin B}{\sin b} = \frac{\sin C}{\sin c};$$

an important theorem, which may be readily established directly. The combination of the last with the first formula leads at once to the following, from which five others may be deduced by mere permutations of letters:—

$$\cot a\sin b = \cot A\sin C + \cos b\cos C.$$

In virtue of the properties of Supplemental Triangles, we may deduce from the foregoing as many new formulæ, by replacing a, b, c, A, B, C, by $\pi - A$, $\pi - B$, $\pi - C$, $\pi - a$, $\pi - b$, $\pi - c$, respectively. To the above, we will add the following, which, with their supplemental formulæ, are known as *Napier's Analogies*:—

$$\left.\begin{aligned} \tan\tfrac{1}{2}(A+B) &= \frac{\cos\frac{1}{2}(a-b)}{\cos\frac{1}{2}(a+b)}\cot\frac{C}{2} \\ \tan\tfrac{1}{2}(A-B) &= \frac{\sin\frac{1}{2}(a-b)}{\sin\frac{1}{2}(a+b)}\cot\frac{C}{2}, \end{aligned}\right\}$$

and the following four, which are known as *Gauss's Theorems*, although discovered by Delambre:—

$$\left.\begin{aligned} \cos\tfrac{1}{2}(A+B)\cos\tfrac{1}{2}c &= \cos\tfrac{1}{2}(a+b)\sin\tfrac{1}{2}C \\ \cos\tfrac{1}{2}(A-B)\sin\tfrac{1}{2}c &= \sin\tfrac{1}{2}(a+b)\sin\tfrac{1}{2}C \\ \sin\tfrac{1}{2}(A+B)\cos\tfrac{1}{2}c &= \cos\tfrac{1}{2}(a-b)\cos\tfrac{1}{2}C \\ \sin\tfrac{1}{2}(A-B)\sin\tfrac{1}{2}c &= \sin\tfrac{1}{2}(a-b)\cos\tfrac{1}{2}C \end{aligned}\right\}$$

The above formulæ serve to solve all possible cases of spherical triangles, where, three elements being given, it is required to determine the remaining three.

By putting one of the angles equal to 90°, we obtain the six formulæ for the solution of

right-angled triangles; all of which, however, may be easily written down by means of *Napier's rules of circular parts*. [CIRCULAR PARTS.] From the supplemental formulæ, which we have not thought it necessary to give, the six corresponding formulæ for the solution of quadrantal triangles are deduced by making a, b, or c, equal to 90°. With respect to the superficial area of a spherical triangle, see SPHERICS and SPHERICAL EXCESS.

Trigonous (Lat. trigonus, Gr. τρίγωνος, *three-cornered*). In Botany, this term is applied to bodies having three angles and three plane faces, as the stems of *Carices*.

Trilateral (Lat. trilaterus, from latus, lateris, *a side*). Three-sided; a term applied to all triangular figures.

Trilinear Co-ordinates. [CO-ORDINATES.]

Trilliaceæ (Trillium, one of the genera). A small order of Endogens, distinguished by their simple stems, bearing a whorl of netted-veined leaves, and a single terminal flower, usually with three herbaceous sepals, three larger petals, six to ten stamens with linear anthers, a free ovary with three to five cells and as many distinct styles, and a succulent fruit. The species are all natives of the temperate regions of the northern hemisphere, and are distributed into five or six genera. The fleshy roots of *Trillium erectum*, under the name of Beth-root, form one of the numerous drugs prepared for sale in the United States by some of the societies of the religious sect called *Shakers*. They are esteemed astringent, tonic, and antiseptic, and are employed in spitting of blood and several other complaints. The plant is also called *Indian Balm* or *Lamb's Quarters*. It has an erect stem a foot or more high, bearing three broad almost rhomboid leaves, and drooping fetid flowers, with green sepals striped with purple, and deep purple petals.

Trillion. In Arithmetic, a million of billions, or a million of million of millions. The term is said by Dr. Johnson to have been invented by Locke.

Trillo (Ital.). In Music, a SHAKE. It is abbreviated *tr*.

Trilobites (Gr. τρίλοβος, *three-lobed*). The name given by Cuvier to an order of Crustaceans, comprehending those remarkable fossil species in which the body is divided into three lobes by two fissures which run parallel to its axis.

Trilogy (Gr. τριλογία). This word is applied to a series of three dramas, which, although each of them is in one sense complete, yet bear a mutual relation, and form parts of one historical and poetical picture. The *Agamemnon*, *Choephoræ*, and *Eumenides* of Æschylus, and the *Henry IV.* of Shakspeare, are examples of a *trilogy*.

Trim (A.-Sax. trum). The position of the keel of a ship with respect to a horizontal line. Also the disposition of the weights or stowage, as favourable or otherwise for sailing, which are expressed by *in trim* and *out of trim*.

Trimerans (Gr. τριμερής, *tripartite*). The name of a section of Coleopterous insects, including those which have each tarsus composed of three articulations.

Trimethylamine. An organic base resembling triethylamine, but containing the radical methyl instead of ethyl.

Trimmer. In Architecture, a piece of timber framed at right angles to the joists opposite chimneys or the well-holes of stairs; it receives the ends of the joists intercepted by the opening.

Trimming Joist. In Architecture, a joist into which a trimmer is framed.

Trimyaries (Gr. τρεῖς, and μυών, *a muscle*). The name by which those Bivalves are distinguished which present three muscular impressions on each valve.

Trinacrite. A micaceous mineral of a dull-brown colour from Sicily (the ancient Trinacria).

Trine (Lat. trini, the distributive of tres, *three*). Of threefold dimensions—length, breadth, and thickness. In Astrology, the trine was one of the five aspects (a benign one) of the influential bodies. [ASTROLOGY.]

Tringa. A genus of wading birds (*Grallæ*), characterised by a compressed bill of moderate length, enlarged at the point, and a hind toe, too short to reach the ground. It is by the latter character that the lapwings (*Tringæ*) are distinguished from the plovers (*Charadrii*), in which the hind toe is wanting.

Trinitarians. A general name for those who believe in the TRINITY.

The word also denotes a religious order, founded in 1198 under the pontificate of Innocent III. Its members devoted themselves especially to the duty of ransoming captives taken by the Moors and other infidels. Another body of Trinitarians was formed in consequence of a reformation of the order in 1578. There was also an order of the same name for women, dedicated to the same objects.

Trinity (Lat. Trinitas). A name employed to denote the three Persons comprised in the Godhead, and distinguished as the Father, the Son, and the Holy Ghost. The term is not found in the books of the New Testament, and its introduction is referred at the earliest to the second century. [THEOLOGY.]

Trinity House. The Trinity House was incorporated by Henry VIII. in 1515, for the promotion of commerce and navigation, by licensing and regulating pilots, and ordering and erecting beacons, lighthouses, buoys, &c. The corporation is governed by a master, wardens, assistants, and elder brethren. Its privileges and powers were confirmed by a charter of James II., and have been extended and defined by the Merchant Shipping Act of 1854.

Trinity Sunday. The Sunday next after Whit Sunday; so called on account of a feast which was held anciently, and still continues to

be held, on that day in honour of the Holy Trinity. This feast does not appear to have been fully established in the Western Church until the year 1334, under Pope John XXIII.

Trinoda Necessitas. [BOCLAND.]

Trinomial (Lat. tres, *three*, and nomen, *name*). In Algebra, a quantity consisting of three terms connected by the signs + or −; as $a^2 + bc^2 - d^3$.

Trinragan. An Eastern name of the Palmyra Palm.

Trio (Ital.). In Music, a composition consisting of three parts.

Tricecious (Gr. τρεῖς, *three*, and οἶκος, *a house*). In Botany, a term applied to designate those plants which have male flowers on one individual, female on another, and hermaphrodite on a third.

Triolet. A stanza of eight lines, in which the first line is thrice repeated.

Triones (Lat.). In Astronomy, the seven principal stars in the constellation Ursa Major, popularly called Charles's Wain; four of the stars being fancied to represent a wain or waggon, and the three others the oxen by which it is drawn. [RISHIS, THE SEVEN.]

Trioxide or **Teroxide.** In Chemistry, such oxides as contain one atom of element united to three atoms of oxygen.

Tripe (Fr.; Ital. trippa, Span. tripa). The first and second stomachs of ruminants, when properly prepared, constitute *tripe*.

Tripe de Roche (Fr.). A name given in North America, from their blistered thallus, to several species of *Gyrophora* and *Umbilicaria*, especially the latter, which afford a coarse food, whose nutritive qualities are, however, much impaired by the presence of a bitter principle which is apt to cause serious diarrhœa. Bad, however, as rock tripe is, it has done good service to some of our arctic voyagers, especially to the expeditions under the lamented Sir John Franklin. In no case, however, did it completely appease the pangs of hunger, probably from its not containing in the proper proportions all the constituents which are necessary to compose a truly nutritious article of food. Some of these lichens, of large size, have been found on the farthest northern land which has yet been explored.

Tripe-stone. The name given to a particular form of Anhydrite from Wieliczka and Bochnia in Poland, which bears a sort of outward resemblance to the convolutions of the intestines.

Triphane (Gr. τριφανής, *appearing threefold*). A Mineralogical synonym of Spodumene.

Triphthong (Gr. τρεῖς, and φθογγός, *a voice*). In Grammar, a composite sound of three vowels, as a diphthong is of two; such as the German *aeu*. There is no such sound in English, nor, strictly speaking, in French, unless the combinations *ieu* in that language be so considered.

Triphyline (Gr. τρεῖς, and φυλή, *a clan*). A triple phosphate of lithia, manganese, and iron, found commonly in coarsely granular crystalline masses of a greenish-grey colour, at Rabenstein in Bavaria.

Triphyllous (Gr. τρίφυλλος, *three-leafed*). In Botany, a term applied to those plants which have their leaves in whorls of three, or to those which produce only three leaves.

Triple (Lat. triplex). In Music, one of the kinds or measures of time, of which there are many different subdivisions. There are, however, only four principal ones, of which the others are varieties. [MUSIC.]

Triple Phosphate. The phosphate of ammonia and magnesia (MgO, NH_4O, HO, PO_5), which sometimes forms urinary calculi.

Triple Tangent Line of a Surface. A right line which touches the surface three times, or which meets it in three pairs of coincident points. To be so touched, the order of the surface must exceed the fifth, and when it does so there will in general be an infinite number of triple tangent lines, situated on a ruled surface, since a line in space requires four conditions for its complete determination. According to Dr. Salmon (*An. Geom. of Three Dimensions*), the points of contact of triple tangent lines are on the intersection of the given surface of the n^{th} order with one whose order is—

$$\tfrac{1}{2}(n-2)(n-4)(n-5)(n^2+5n+12).$$

If of the three points of contact of a triple tangent line two coincide, it will become an inflexional tangent which touches the surface elsewhere. Triple tangent lines of this kind lie on a surface of the order—

$$n(n-3)(n-4)(n^2+6n+4),$$

and the points of contact at which the lines are inflexional tangents lie on a surface of the order $(n-4)(3n^2+5n-24)$, whilst the points at which the lines in question are simple tangents lie on a surface of the order—

$$(n-2)(n-4)(n^2+2n+12).$$

When all three points of contact coincide, the triple tangent line becomes what Dr. Salmon terms a *double inflexional tangent*, since, meeting the surface in four consecutive points, it may be regarded as an inflexional tangent at two of them. The locus of the points of contact of such tangent lines is the intersection of the original surface with another of the order $11n-24$, possessing interesting properties, and the lines themselves generate a surface of the order $2n(n-3)(3n-2)$.

Triple Tangent Plane of a Surface. A plane which touches the latter at three distinct points. According to Salmon, the number of such planes, for a surface of the n^{th} order, is—

$$n(n-2)(n^7-4n^6+7n^5-45n^4+114n^3-111n^2 + 548n-960).$$

Triplets. In Poetry, three verses rhyming together.

In Music, notes grouped together by threes; thus, . In common time, where

three of the quavers are intended to be equal in duration to a crotchet, a 3 is sometimes placed over them; but they are generally known by being grouped together, and thus form one of the single parts of the whole measure.

Triplicate Ratio. The triplicate ratio of two numbers or magnitudes is the same as the ratio of the first to their fourth proportional. It is equal to the cube of their ratio, or the ratio of their cubes, in the case of numbers.

Triplite (a word coined from Gr. τρεῖς, and λίθος, *stone*). A mineral composed of phosphoric acid in combination with the protoxides of iron and manganese, which occurs of a pitch-black to a clove-brown colour, in compact crystalline masses with a lamellar structure, and a cleavage in three directions at right angles to each other, near Limoges in France, in a quartz-vein traversing granite; also at Peilau in Saxony.

Tripod (Gr. τρεῖς, *three*, and πούς, *a foot*). In Architecture, a vessel, table, seat, or instrument having three feet. It was from such a seat that the Pythian goddess rendered oracular answers at Delphi.

Tripoli. The name of a powder greatly used in polishing metals, stones, &c., and consisting almost exclusively of the silicious portion of the cases of infusorial animalcules and *Diatomaceæ*, divested of everything except the silex. It was first imported from Tripoli, whence its name. Many other localities are now known in which the same material is found. Ehrenberg estimated that forty thousand millions of individuals of *Gaillonella distans* were contained in each cubic inch of the tripoli from Bilin, a well-known locality in Bohemia, where there is a deposit of it fourteen feet thick extending over a wide area.

Several of the species of which this powder is composed are found to be identical with those which are at the present day contributing to form a sediment on the Victoria Barrier, in the Antarctic regions, hundreds of miles in length. The Phonolite stones of the Rhine also abound in the remains of *Diatomaceæ*.

Triptolemæa. A group of Brazilian *Leguminosæ*, now by the best authorities united with *Dalbergia*, an extensive genus common to the tropics of both hemispheres. The *Triptolemæas* are trees or woody climbers, with alternate pinnate leaves. The Rosewood of commerce, imported from Brazil, was for a long time supposed to be yielded by this genus upon the authority of the French traveller and botanist Guillemin, who brought from Brazil specimens of two species of *Triptolemæa* as the true rosewood plant; but, according to Dr. Allemão of Rio Janeiro, the greater part of the best kind of rosewood sent to Europe is the wood of *Dalbergia nigra*, while other qualities are the produce of species of *Machærium*. [ROSEWOOD.]

Triptolemus (Gr. Τριπτόλεμος). Many parents are assigned to this hero of Greek Mythology, who, according to Apollodorus, is a son of Keleos, king of Eleusis, in whose house Dêmêtêr rested during her woeful pilgrimage in search of PERSEPHONÊ. To requite the kindness of the daughters of Keleos, Dêmêtêr wished to render Demophon, the infant brother of Triptolemus, immortal. She therefore plunged the child by night into a fire; but his mother, Metaneira, discovering what Dêmêtêr was doing, screamed out, and the babe was consumed by the fire, while Dêmêtêr revealed herself in her true character, and gave to Triptolemus a chariot, drawn by winged dragons, and corn with which he sowed the whole earth, thus providing bread for the children of men. This dragon-chariot is manifestly the same as the chariots of Medeia and of Helios, drawn by winged beings, who are the Harits or the CHARITES.

By Hyginus, Triptolemus is represented as a son of Eleusis, and as being the child whom Dêmêtêr wished to render immortal. In this version Eleusis, and not his mother, discovers the secret deed of Dêmêtêr, and is by her immediately put to death.

In the Athenian Mythology, Triptolemus instituted the feast called *Thesmophoria* in honour of the goddess, and was the great hero in the Eleusinian mysteries, the plough and agriculture being regarded as his special gifts to men.

Triptote (Gr. τρίπτωτος). In Grammar, a noun that has only three cases.

Trireme (Lat. triremis, Gr. τριήρης, *a galley with three rows of oars*). The usual war vessel of the Greeks at the time of the Persian and Peloponnesian wars. [GALLEY; PENTECONTORI; QUINQUEREMIS.]

Some light has been thrown on Athenian naval matters by the discovery of some inscriptions at the Piræeus, which have been commented on by Boeckh. (*Public Economy of Athens*, transl. i. 372 &c.)

Trisagion (Gr. τρισάγιος, *thrice holy*). In the Greek Church, the threefold invocation of the Deity as 'Holy' (Lat. tersanctus). This invocation takes its origin from Isa. vi. 3, Rev. iv. 8. The ordinary form is that in Isaiah, 'Holy, holy, holy, Lord God of hosts, all the earth is full of Thy glory.' A different form of the trisagion is repeated daily in the service of the Greek church, and is attributed to Saint Proclus.

Trisection of an Angle. A Geometrical problem of great celebrity among the ancient Greek mathematicians. The indefinite trisection of an angle cannot be effected by plane geometry, i.e. by means of the straight line and circle, inasmuch as the analytical equation on which it depends rises to the third degree; but it may be accomplished by means of the conic sections and some other curves. [QUADRATRIX.]

Pappus of Alexandria, in the fourth book of his *Mathematical Collections*, reduces the problem to that of drawing a line through a given point so that the intercept upon it made by two given lines, at right angles to each other, shall be double the distance of the intersection of these lines from the given point. He also

shows how this problem may be solved by means of a hyperbola.

Trismus (Gr. τρισμός). Lockjaw; tetanus affecting the jaw.

Trispast or **Trispaston** (Gr. τρίσπαστος, *drawn threefold*). A machine with three pulleys acting in connection with each other for raising heavy weights.

Tritheism (Gr. τρεῖς, and Θεός). In controversial theology, the name applied to an opinion which is the reverse of SABELLIANISM.

Trithionic Acid. An unstable acid of sulphur, produced by heating a solution of sulphite of potash with sulphur.

Triticum (Lat.). A genus of grasses, including, with the Common Wheat, the equally common Creeping Couch, one of the most troublesome weeds of the farm. *T. vulgare* is an annual cereal or corn grass, which under the name of Wheat is well known to everyone, but its native country and origin have ever been curious subjects of speculation. M. Fabre's experiments afford very strong reason to conclude that this cereal is derived from a wild grass of Southern Europe and Western Asia, known to the botanist as *Ægilops*. Though at first sight appearing to be very different from wheat, it is really not so on a minute examination of its parts, and indeed in cultivation soon affords a very respectable grain; its green herbage, too, emits on being bruised the peculiar smell which belongs to wheat, and like wheat it is subject to the same epiphytes or attacks of *blight*. That a plant very dissimilar from wheat, in fact a wild useless grass, should yet in cultivation become so changed as to afford a useful grain, leads us to expect, from this amount of adaptability to circumstance, that it would be capable of easily affording a large variety of sorts. Such we know to be the case, and hence few plants are so easily adapted to every climate, soil, and management as wheat.

T. repens, the Couch, is far too well and unfavourably known. *T. caninum* differs from it mainly in the absence of the running underground stems (rhizomes). It has, however, the same pungent flavour which belongs to all the *Tritici*, due probably to the presence of some kind of essential oil, in virtue of which it would appear to be capable of exerting powerful emetic action, at least on dogs. [WHEAT.]

Tritogeneia. [MINERVA.]

Tritomite (Gr. τρίτομος, *thrice-cut*). A hydrous mineral related both in form and composition to Helvine and Garnet. It is found in the syenite of the island Lamö in Norway.

Triton (Gr.). In the Homeric Mythology, a son of Poseidon and Amphitritê; but Tritons are sometimes mentioned in the plural. The word recurs in the Vedic Tritæ [THRAÊTANA], as well as in the Greek Tritogeneia, Tritopatreus, &c. [MINERVA.]

TRITON. In Zoology, the name *Tritonia* has been given to a genus of marine, naked, gastropodous Molluscs, or sea-slugs.

Tritone (Gr. τρίτονος, *of three tones*). In Music, an interval, now generally called a *sharp fourth*, consisting of four degrees, and containing three whole tones between the extremes, on which account the ancients gave it its name. It is moreover divisible into six semitones, three diatonic and three chromatic.

Tritopatreus. A son of Zeus and Persephonê, and one of the Dioscuri. [POLYDEUKÊS; TRITON.]

Trityl. [PROPYL.]

Triumph (Lat. triumphus, Gr. θρίαμβος). The highest military honour that could be obtained by a Roman general. It was a solemn procession, with which the victorious leader and his army advanced through the city of Rome to the Capitol, accompanied by the captives taken in war, and vehicles bearing the spoils and all the furniture that could add magnificence to the spectacle. On arriving at the Capitol, the general offered up a prayer of thanksgiving to Jupiter and the other gods, and sacrificed white bulls. A triumph was decreed by the senate, and sometimes by the people against the will of the senate, to the general who in a just war with foreigners, and in one battle, had slain above 5,000 enemies of the state, and enlarged the limits of the empire. [OVATION.]

Triumphal Arch. In Architecture, an arch erected to perpetuate the memory of a conqueror, or of some remarkable victory or important event. At first it consisted of a single arch, decorated merely with a statue and spoils of the victorious commander; but arches were afterwards erected with two, and then with three, passages.

Triumvirate. In Ancient History, this term was applied to two great coalitions of the three most powerful individuals in the Roman empire for the time being. The first of these was effected in the year 60 B.C. between Julius Cæsar, Pompey, and Crassus, who pledged themselves to support each other with all their influence. (For a defence of this alliance on the ground of public spirit, see the remarks of Napoleon III. in his *Life of Cæsar*, book ii. ch. iv.) This coalition was broken by the fall of Crassus at Carrhæ in Mesopotamia; soon after which the civil war broke out, which ended in the death of Pompey, and establishment of Julius Cæsar as perpetual dictator. After his murder, 44 B.C., the civil war again broke out between Antony, who wished to avenge the death and succeed to the fortunes of Cæsar, and the republic, on whose side were ranged Octavius and Brutus. Lepidus with a large army remained in suspense which side to take. But after the battle of Mutina, in which both consuls fell, 43 B.C., Antony, Octavius, and Lepidus coalesced; thus forming the second triumvirate, each party confirming the bond of union by the sacrifice of some of his own friends to the hatred of the others; among these was Cicero, who was delivered up by Octavius to the vengeance of Antony. Against

this confederation Brutus still held out with the rest of the conspirators who had overthrown Cæsar, till their destruction at the battle of Philippi. The triumvirs then divided the provinces of the empire, Octavius taking the west, Lepidus Italy, and Antony the east; but the union was soon broken by the passion of Antony for Cleopatra, which induced him to repudiate Octavia, the sister of Octavius. War ensued, which was terminated by the defeat and death of Antony at Actium, in 32 B.C.; after which everything fell into the hands of Octavius, Lepidus offering no obstacle.

Triuridaceæ (Triuris, one of the genera). A small order of Endogens, consisting of slender colourless herbs, often almost transparent, without any other leaves than small scales, and small flowers either solitary or in terminal racemes. In their usually six-parted perianth, hypogynous stamens, distinct carpels, and apparently homogeneous embryo, they are connected with *Alismaceæ*, from which they differ chiefly in the divisions of the perianth being always valvate in a single series, and in their embryo not being curved. These curious little plants are generally found, like the smaller *Burmanniaceæ*, on rotten leaves or other decaying vegetable matter in the moist tropical forests of both the New and the Old World.

Trivium (Lat trivius, *of three ways*). The name given in the schools of the middle ages to the first three liberal arts (grammar, rhetoric, and logic), which were studied together. The other four (arithmetic, music, geometry, and astronomy) formed what was termed the *quadrivium*: and the two following mnemonic lines comprehend the whole:—

> Gram. loquitur; Dia. verba docet; Rhe. verba ministrat;
> Mus. canit; Ar. numerat; Ge. ponderat; As. colit astra.

Trocar. An instrument used in tapping for the dropsy. The name is said to be corrupted from the French *trois-quarts*, from the three sides of its point.

Trochanter (Gr. τροχαντήρ, *a runner*; because the muscles inserted into it are those chiefly concerned in the act of running). A name given to two processes (greater and less trochanter) at the upper end of the thigh bone. In the odd-toed (perissodactyle) Mammalia, a large process is developed in the middle of the thigh bone, to which the term *median trochanter* is applied.

Troche (Gr. τροχός, *a wheel*, from τρέχω, *I run*). A small round lozenge or cake, generally composed of sugar and mucilage, united with small portions of more active remedies, intended to be allowed gradually to dissolve in the mouth.

Trochee (Gr. ὁ τροχαῖος, sc. πούς). A rhythmical measure consisting of two syllables, a long and a short; thus, – ⏑.

Trochilus (Gr. τροχίλος). The trochilus, according to Herodotus, was a bird which plucked βδέλλαι (*leeches*; he should have said *flies*) out of the crocodile's mouth. By Pliny the name seems to have been applied to the wren. Linnæus uses the word to denote the genus of small and brilliantly coloured birds which, from the energy and rapidity of the vibrations of their wings during flight, are called *humming-birds*. This genus includes the smallest of the feathered tribe, and, if we except a few fishes, the most diminutive of vertebrated animals. Some humming-birds scarcely exceed a humble-bee in size; they are unable to escape from the strong webs of the large spiders of the American tropics, and thus sometimes become their prey.

The humming-birds are characterised by a long and slender bill, enclosing an extensile bifid tongue, by which they extract the nectar and the small insects which may lurk in the recesses of flowers. They have very small feet, long and narrow wings, a broad and entire sternum with an unusually deep keel, and a short and strong humerus; all combining to form a mechanism for rapid and powerful flight, like that of the swift. Humming-birds live in pairs: they have the character of being very quarrelsome, the males fighting desperately with each other: both sexes combine to defend their nests with courage.

Trochlea (Lat.; Gr. τροχαλία). In Anatomy, this term is applied to the cartilage through which the tendon of the *trochlearis muscle* passes. It is the superior oblique muscle of the eyeball, and is accompanied by the *trochlearis nerve*.

TROCHLEA. In Mechanics, the same as *pulley* or *tackle*. [PULLEY.]

Trochoid (Gr. τροχοειδής, *like a wheel*). The curve described by a point on the radius of a circle when the latter rolls on a right line. The trochoid becomes a CYCLOID when the describing point is at the extremity of the radius, i.e. on the circumference of the rolling circle.

Trochus (Gr. τροχός). The name given by Linnæus to a genus of the *Vermes Testacea*, characterised by a subconical spiral shell, with the margin entire, without a fissure or canal for the siphon of the mantle, the animal not possessing any respiratory tube. The mouth of the shell is closed by an operculum, or some analogous part. The species to which the characters of the Linnæan genus are applicable constitute a family of Pectinibranchiate Gastropods in the system of Woodward, called *Trochidæ*, which includes the following genera: *Turbo*, *Phasianella*, *Imperator*, *Trochus Elenchus*, *Rotella monodonta*, *Delphinula*, *Cyclostrema*, *Euomphalus*, *Ophileta*, *Phanerotinus*, *Stomatella Gena*, *Broderipia*. The Gastropod called *Turbo pica* by Linnæus, having been ascertained to have an operculum, is now referred to the genus *Trochus*.

Troglodytes (Gr. τρωγλοδύτης, from τρώγλη, *cave*, and δύω, *I enter*). Tribes of men who have their dwellings in subterraneous caverns. Several such tribes are mentioned by ancient authors, and the remains of their dwellings still attest their existence, especially along the banks of the Nile, in

Upper Egypt and Nubia, and in parts of Syria and Arabia.

The chimpanzee has been called by Blumenbach *Simia Troglodytes*.

Trolls. In Teutonic Mythology, a race of beings engaged in a perpetual struggle with men, just as the Frost Giants of Utgard, the outer world, waged a continual war with the Æsir who dwelt on Asgard, a lofty hill in the centre of Mitgard, the habitable world (answering to Delos, as the γῆς ὀμφαλός of the Greeks). These Trolls are superior to man in strength and stature, but far beneath him in mind. In short, they are always outwitted, just as the Greek Titans are overcome by Zeus when aided by Prometheus, the forethinker. The Trolls thus embody the idea of unintellectual brute force, or mere awkward strength; it must, however, be remembered that the Trolls are not the only beings who, formidable in some respects, are still defeated by man. The idea of a devil has been traced to Iranian DUALISM. Although this idea seems to be absent from the prophetical books of the Old Testament, it was fully developed before the Christian era; and thus it was disseminated among the nations of Northern as of Southern Europe. In the mind of the former the notion seems to have found at first no congenial soil; and thus the Teutonic devil is exhibited for the most part as an unprincipled simpleton, who is constantly brought into ludicrous or contemptible positions. This stupidity in the Trolls has by some been accounted for on the ground that they represent the old aboriginal races who retired into the mountainous fastnesses of the land, and whose strength was exaggerated because the intercourse between the races was small. (Dasent, *Popular Tales from the Norse*, lviii.) If we cannot in terms deny, we have no evidence to warrant us in upholding this euêmeristic interpretation. It may, however, be remarked that the Northern mythology, like that of the Greeks, peopled every spot of earth, seas, mountains, lakes, stream, trees, woods, with its own superhuman inhabitants; that the systems of both were coloured in accordance with the conditions of soil and climate in their respective countries; and that the characteristics of the Æsir, the Frost Giants, the Trolls in the one case, and of the Olympian gods, the Titans, the Giants in the other, seem to be fully accounted for by the physical differences which distinguish Northern Europe from the countries on the Mediterranean Sea.

Trombolite. [THROMBOLITE.]

Trombone (Ital.). A brass musical wind instrument, somewhat similar in form to the trumpet, but larger, and made with a slide, by means of which the intonation can be regulated, and the complete scale played. There are three sizes of trombones, playing alto, tenor, and bass respectively; these are also used with much effect in the modern orchestra.

Tron Weight. The most ancient of the weights used in Scotland; and though its use is now prohibited by law, it is still occasionally employed in some of the rural districts in weighing wool, cheese, butter, &c. The tron pound was not a well-defined weight, but varied from 21 to 28 ounces avoirdupois.

Trona. Native sesquicarbonate of soda; composed, when pure, of 37·8 per cent. of soda, 40·2 carbonic acid, and 22 water. It is found for about ten miles along the coast east of Aden, Suckena in Africa, Barbary, Columbia [URAO], South America, &c., generally in fibrous masses composed of a congeries of minute white crystals, inclining to yellowish-grey when impure.

Troop (Fr. troupe; Ger. trupp; probably akin to Lat. turba, Gr. τύρβη). In cavalry, the unit for discipline, corresponding to *company* in the infantry. Each troop on home service at present consists of three officers, five sergeants, and sixty-three rank and file.

Troostite. A variety of Willemite containing 2 per cent. of carbonate of protoxide of manganese; and named after Dr. Troost, of Nashville College, Tennessee. It is a ferruginous silicate of manganese, and is found at Stirling in New Jersey.

Tropæolaceæ. An order established for the genus *Tropæolum*, which, formerly placed in *Geraniaceæ*, has been repeatedly separated from it, but is again reunited, especially on account of the close affinity which the structure of its flowers exhibits to that of *Pelargonium*.

Tropæolum (Lat. tropæum; Gr. τρόπαιον, *a trophy*). An extensive genus of herbs, representing the group (or order) *Tropæolaceæ*, and consisting of climbing plants, all South American, many of them in cultivation, and of an ornamental character. The *Tropæolums* are remarkable for possessing an acrid taste, similar to that which exists among the *Cruciferæ*; and two of the species are grown for culinary purposes, *T. majus* and *T. minus*.

T. majus, the Indian Cress or Nasturtium, is a hardy annual, native of Peru, of trailing habit, but which, when its succulent stems can obtain any bush for support, will attach itself by means of the long twining petioles, and attain a considerable height. The flowers are large and showy, and the seeds consist of three conjoined berries or nuts, with grooved wrinkled gibbous husks, which become fungous when dry. The flowers and young leaves are frequently used to mix in salads. They have a warm taste, not unlike that of the common cress, from which circumstance the plant has obtained the name of Nasturtium. The berries are gathered when young and quite green, and make, without the aid of spice, an agreeable pickle, which, as well as the green leaves steeped in vinegar, is accounted a good antiscorbutic, and also forms an excellent substitute for capers. *T. minus* is very similar in appearance to *T. majus*, but is smaller in every respect, and of dwarf weak growth. The seed-pods are also small, on which account they are considered preferable to those of *T. majus* for pickling as a substitute for capers.

Trope (Gr. τρόπος, from τρέπω, *I turn*). In Rhetoric, literally any expression *turned* from

its primary signification, and employed in a sense derived in some manner from that primary signification. In this sense, the general term *trope* comprises the various figures termed ALLEGORY, METAPHOR, METONYMY, SYNECDOCHE, and perhaps several others. By the natural progress of language, words or phrases at first employed as tropes become impressed so strongly with their new or derivative signification, that they finally lose the original.

Trophi (Gr. τροφός, from τρέφω, *I nourish*). A name given by Kirby to the different instruments of, or organs contained in the mouth of insects, or closing it, and employed in manducation or deglutition. They include the *labrum*, *labium*, *mandibulæ*, *maxillæ*, *lingua*, and *pharynx*.

Trophonius (Gr. Τροφώνιος). In Greek Mythology, a son of Erginus, king of Orchomenos, who, together with his brother Agamedes, built the temple of Apollo at Delphi. He prayed for a reward from the god, which was promised him on the seventh day, on which he and his brother were both found dead. The story is also told in other ways. He had a temple at Lebadea, in which was the celebrated cave into which persons descended to consult the god. But the impressions produced by the descent were thought so to work upon the spirit of a visitor, that he remained a victim to melancholy the remainder of his life. Hence arose the proverb applied to a serious man—that he looked as if he came out of the cave of Trophonius.

Trophsperm (Gr. τρέφω, *I nourish*, and σπέρμα, *a seed*). A name given by some French botanists to the placenta of a plant.

Trophy (Gr. τρόπαιον, from τρέπω, *I turn*). A monument consisting of some of the arms of slain enemies, hung upon the trunk of a tree, or a stone pillar, by a victorious army, in token of its victory and the flight of the enemy; whence its name. Trophies were always dedicated to some deity, whence it was deemed sacrilegious for any one to injure or demolish them; while at the same time it was forbidden to repair them when decayed. (Paris ix. 40; see, as to Roman trophies, *Mém. de l'Acad. des Inscr.* xxiv. 32.)

Tropical Year (Gr. τροπικός, *belonging to a turn*). The time between the sun's leaving a tropic and returning to it. Popularly it means the time from the longest day in one year till the longest in the next. [YEAR.]

Tropics. In Astronomy, the parallels of declination between which the sun's annual path in the heavens is contained, the distance of each from the equator being equal to the sun's greatest declination. The northern tropic is called the tropic of Cancer, and the southern one that of Capricorn, from their touching the ecliptic in the first points of those signs.

The distance of the tropics from each other is equal to the difference between the greatest and least meridian altitudes of the sun, observed at any place whose latitude is greater than the obliquity of the ecliptic. [ECLIPTIC.]

Tropidonotus (Gr. τρόπις, *a keel*, and νῶτος, *the back*). A genus of non-venomous serpents, nearly allied to the true Colubers, but with bodies thicker in proportion to their length; the back more keel-shaped, and the abdomen more expanded and convex; the head is large and conical, with a slender and short muzzle. The species seldom exceed three or four feet in length; they live near fresh-water streams, and are good swimmers: they are confined to the Old-World continents, and are replaced in South America by the genus *Homalopsis*. The *Coluber scaber*, Linn., a serpent of the Cape of Good Hope, remarkable for the presence of teeth in the œsophagus, and their absence from the mouth, is referred to the genus *Tropidonotus* by Schlegel.

Troubadours (Ital. trovar, Fr. trouver, *to find*). A school of poets who flourished from the eleventh to the latter end of the thirteenth century, principally in the South of France, but also in Catalonia, Arragon, and the north of Italy. They wrote in varieties of the Provençal or Romance language, also called in the middle ages *Langue d'oc*. They flourished under the counts of Toulouse, Barcelona, and Provence; and their minstrelsy and peculiar spirit declined from the time of the crusade against the Albigenses, when the former of these noble houses was vanquished and humiliated, and their land overrun by the sterner adventurers of the north. The most renowned among the Troubadours were knights, who cultivated poetry as an honourable accomplishment; but their art declined in its later days, when it was chiefly cultivated by minstrels of a lower class. The names and some of the productions of more than 200 Troubadours have been preserved, and among their numbers are to be found kings, dukes, counts, and warriors of historical celebrity. The most remarkable characteristics of the Provençal poetry were its almost entire devotion to the subject of romantic gallantry, and the very complicated character, in general, of its metre and rhymes. The principal species of composition cultivated by the Troubadours were *tenzones*, or poetical contests between two minstrels; sometimes breathing satire or defiance, sometimes rivalling each other in the praise of their ladies, sometimes aiming at mere exertions of verbal ingenuity; *sirventes*, pieces devoted to martial and other serious subjects; short songs, or *chansons*; and a variety of other lyrical strains, *soulas*, *lais*, *pastourelles*, *arbades*, *serenades*, *retronage*, and *redondes*. The earliest Italian poets framed their style of thought and versification closely after the model afforded them by the Troubadours. (Sismondi, *Literature du Midi de l'Europe*, vol. i.; the works of M. Raynouard; Lewis's *Researches into the Romance Language*; Schlegel, *Obs. sur la Langue et Lit. Provençale*; Milman, *Latin Christianity*, book xiv.; Hallam, *Literary History of the Middle Ages*, ch. ix. part i.; *National Review*, July 1858, p. 74; Thierry, *Conquête de l'Angleterre par les Normands*, iii. 221.)

Trough of the Sea. The low portion between the lines of crests of two waves. Waves being raised by the wind, the trough must be at right angles to its direction. Hence to be lengthways in the trough is the worst position for a ship in regard to rolling.

Trous de Loup (Fr.). In Military operations, rows of pits in the form of inverted cones, and with a pointed stake in each. They form an obstacle to the advance of cavalry. They should not be more than two and a half feet deep, lest the enemy's riflemen should make use of them.

Trout (A.-Sax. truht). This name is restricted properly and specifically to the *Salmo fario* of Linnæus; but is applied in a generic sense to other native species of *Salmo*, the *S. eriox* of Linnæus, which is the *S. salar* of Rondeletius, being called the bull-trout and grey trout; the *Salmo ferox*, the great grey trout, or lake-trout; the *S. trutta*, the salmon-trout, &c. The common trout inhabits most of our lakes and rivers, and is subject to many varieties of colour, proportions, and even of internal structure, as in the stomach of the gillaroo-trout, according to the variations of soil and food. The season of spawning with the trout is generally in the month of October, at which period the gravid fish make their way up the stream to the shallows. Trout are in finest condition from the end of May to September.

Trouvères or **Trouveurs** (Fr. from trouver, *to find*). Another form of the word Troubadour, employed as a name to distinguish the vernacular poets of Northern France from the Provençal Troubadours. The flourishing period of these poets was the era of the Crusades, and to them belong the stories of the Carolingian cycle, of Charlemagne and his peers, of Arthur and his knights, of Roland and the sons of Aymon. The productions of the trouvères were closely imitated by the monkish poets who wrote in Latin, but who seem to have been unaware of the fact that 'no great poet is inspired but in his native language.' (Milman, *Latin Christianity*, book xiv. ch. iv.)

Trover (Fr. trouver, Ital. trovare, *to find*). In Law, an action of tort. It is a species of action on the case [Action], which is employed to try a disputed question of property in goods and chattels. The declaration in trover contained, previously to 1852, a formal allegation that the plaintiff lost, and the defendant found, the goods in question; but this legal fiction is now abolished, and the action is brought on a simple allegation that the defendant converted to his own use, or wrongfully deprived the plaintiff of the use and possession of, the plaintiff's goods.

Troy, War of. Attempts have been made by chronologers to assign a date to the war of Troy, on a retrospective calculation from the opinion of Herodotus that Homer lived some four centuries before his own time, and that the Trojan war was, in the supposed age of Homer, a comparatively recent event. It must, however, be first proved that there was a single author named Homer, for the *Iliad*, or *Odyssey*, or for both [Epic; Homeric Poems], and that there really was an historical Trojan war. On both of these points no evidence, apparently, is forthcoming. Of the author or authors of the *Iliad* we know nothing: and the tale which the Homeric poets have left to us of the struggle to avenge the wrongs and woes of Helen is essentially a story in which the main chain of causation is superhuman, in which the gods mingle visibly with men, and the heroes themselves are the sons or husbands of immortal beings. From this narrative, full of an astounding thaumaturgy, Thucydides, by rejecting all the incidents as utterly improbable, and substituting political motives adequate to explain the movements of the contending forces, has extracted or rather fabricated a story thoroughly probable in itself, but for which we have less historical evidence than for the story of Robinson Crusoe. In short, his thoroughly prosaic and possible narrative is a piece of plausible fiction of no greater value than the version of Dio Chrysostom, which gives an account of the war diametrically opposed to that of the *Iliad*, which represents Paris as the lawful husband of Helen, and Achilleus as slain by Hector, while the Greeks retire, disgraced and baffled, without taking Troy. We are not, perhaps, justified in maintaining the negative position, that no war actually took place in the Troad; but we have as little warrant for asserting that there was. The burden of proof lies on those who assert that the Trojan war is historical, as for those who maintain the existence of gorgons, griffins, and basilisks. 'If,' says Mr. Grote, 'we are asked whether it be not a legend embodying portions of historical matter, and raised upon a basis of truth—whether there may not really have occurred at the foot of the hill of Ilion a war purely human and political, without gods, without heroes, without Helen, without Amazons, without Ethiopians under the beautiful son of Eos, without the wooden horse, without the characteristic and expressive features of the old epical war—like the mutilated trunk of Deiphobus in the under world; if we are asked whether there was not really some such historical Trojan war as this, our answer must be that, as the possibility of it cannot be denied, so neither can the reality of it be affirmed.'. (*History of Greece*, part i. ch. xv.)

But whatever may have been the source of the legend, or its original meaning, it is certain that it became localised in the north-western corner of Asia Minor, just as other myths become localised at Delos, Ortygia, Crete, Athens, and Eleusis. The historical Ilion had its acropolis called Pergamos, in which was shown the house of Priam, and the altar at which he had been slain, and where the panoplies worn by Homeric heroes were exhibited to admiring crowds, who believed

in their genuineness as firmly as the pilgrims to Trèves still believe in the genuineness of the Holy Coat. On the altar where Priam fell, Alexander the Great offered a solemn sacrifice, from the wish to appease the anger of the old Trojan king against the Macedonian stranger who belonged to the race of the Achilleids. The reputation of this historical Ilion was eclipsed for a time by the foundation of Alexandreia Troas, until the Romans granted to it immunity from tribute, with other honours, as being the spot whence their progenitor Æneas had started on his westward wanderings. Hence arose a jealousy between the Ilians and the inhabitants of Alexandreia Troas and other cities, who made an attack on the genuineness of the Trojan sites and ventured to assert that the Homeric Ilion had not occupied the site of the city so called. Whatever may have been the value of these doubts, the legendary faith continued unshaken, and its upholders vindicated for it the weight of authority even against historical impossibilities. 'Hellanikus, Herodotus, Mindarus, the guides of Xerxes, and Alexander had not been shocked by them: the case of the latter is the strongest of all, because he had received the best education of his time under Aristotle; he was a passionate admirer and constant reader of the *Iliad*; he was moreover personally familiar with the movements of armies, and lived at a time when maps, which began with Anaximander, were at least known to all who sought instruction.' To resist such a weight of authority as this, would argue an extreme hardihood of scepticism.

But although it is no part of the historian's office to write the history of a period for which he has no materials coming to him as the known evidence of trustworthy contemporary witnesses, the mythologist may analyse the legendary narrative, and ascertain its points of resemblance or difference, as compared with the epic poems or the traditions of other ages and countries; and something at least is done when the names of many among the chief actors in the struggle are found in the earlier literature of the Hindus. Some steps are gained towards a settlement of the question when we learn that PARIS represents the Pânis who seek to seduce Saramâ (Helen) from her allegiance to Indra, that Briseis recurs in the name Brisaya, that Athênê is Ahanâ, that Achilleus is the solar hero Aharyu. With this must be taken the large number of names which explain themselves [TELEPHASSA], and the analogies in the lives and character of Homeric heroes, and those of other mythical personages, as in the part played by Patroclos, PHAETHON, and TELEMACHOS, by Achilleus, MELEAGROS, and Paris, by Leto [APOLLO] and Hekabe [PARIS], by the agreement in the attributes of Zeus and Dyaus, of Phœbus and Indra, of Erinys and Saranyu, and in the identity of the ideas which underlie and pervade the conceptions of HERACLES, BELLEROPHON, ODYSSEUS, ACHILLEUS, SIGURDR, RUSTEM, THRAÊTANA, Baldr, THESEUS, PERSEUS, ŒDIPUS, and many more.

When the names of the chief actors, and the main incidents, as well as the general thread of the story, are thus found to be common elements in the Teutonic, Vedic, and Iranian mythologies, a presumption is at least raised that the whole epic is entirely mythical, and that it existed independently of any earthly locality, and the political movements of any tribes. In short, the fortunes of a geographical Ilion seem to fade away into the cloudland where the mythical 'Ilion like a mist rose into towers,' and no room is left for controversies whether such epithets as ἠνεμόεσσα, *windy*, or εὐρώδης (*broad*, or, as some would have it, *dark* or mouldy), apply especially to the site of the historical Ilion. If the evidence of comparative mythology be taken, Ilion was as open to the wind as the land of the PHÆACIANS, while εὐρώδης becomes a name quite as applicable to it as to Europa, Euryganeia, Eurymedusa, and other wives or daughters of solar beings.

Thus, then, the ordinary tests of HISTORICAL CREDIBILITY show that the events of the Trojan war could not have taken place in the way related, while comparative mythology has traced the materials of the tale into other ages and countries, between which and the Greeks intercommunication was impossible; and whatever be the opinion entertained as to the character of PARIS as representing the powers of light or darkness, it seems not easy to resist Professor Max Müller's conclusion that, 'apart from all mythological considerations, Saramâ in Sanskrit is the same word as Helene in Greek, and unless we are prepared to ascribe such coincidences as *Dyaus* and *Zeus*, *Varuna* and *Uranos*, *Sarvara* and *Cerberus*, to mere accident, we are bound to trace Saramâ and Helene back to the same point from which both could have started in common. The siege of Troy is but a repetition of the daily siege of the East by the solar powers, that every evening are robbed of their brightest treasures in the West. That siege, in its original form, is the constant theme of the hymns of the Veda. Saramâ, it is true, does not yield in the Veda to the temptation of Pani; yet the first indications of her faithlessness are there, and the equivocal character of the twilight which she represents would fully account for the further developement of the Greek myth. In the *Iliad*, Brisêis, the daughter of Brises, is one of the first captives taken by the advancing army of the West. In the Veda, before the bright powers reconquer the light that had been stolen by Pani, they are said to have conquered the offspring of Brisaya. The daughter of Brises is restored to Achilles when his glory begins to act, just as all the first loves of solar heroes return to them in the last moments of their earthly career.' (Max Müller, *Lectures on Language*, second series, xi.) For the singular parallelism which, even to minute details, runs through

the tales of the final conflict of Achilles and Hector, in the *Iliad*, and that of Odysseus and the suitors in the *Odyssey*, see Cox, *Tales of Thebes and Argos*, Introduction 63–110.

Troy Weight. An English weight chiefly used in weighing gold, silver, diamonds, and other articles of jewellery. The pound troy contains 12 ounces or 5,760 grains, the pound avoirdupois containing 7,000 of such grains. The name is supposed to have reference to the monkish name, given to London, of Troy Novant. [Weights.]

Truce (Mod. Lat. treuga, from the Teutonic treue, *truth*). An agreement between states, or those representing them, for the suspension of hostilities. Such an agreement, when made by officers of the state in the general exercise of their duty, and not authorised for the purpose expressly, or by necessary implification, ranks among that class of conventions which jurists term *sponsions*, and which are binding only if ratified. [Sponsion.] A general armistice or truce differs from a partial truce, which is limited to particular places; as between two armies, or between a besieged fortress and the besieging army. The former, in general, requires ratification: power to include the latter is held to be implied in the general authority of military and naval officers. (Vattel, book iii. ch. xvi.; Wheaton *On International Law*, vol. ii.)

Truce of God (Lat. *Treuga Dei*). A suspension of arms, which occasionally took place in the middle ages, putting a stop to private hostilities. The right to engage in these hostilities was jealously maintained by the inferior feudatories of the several monarchies of Europe. But it was restrained by the repeated promulgation of these truces, under the authority of the church. Thus, in the county of Roussillon, A.D. 1027, it was determined in a synod of the clergy, that no man should attack his enemy from the hour of nones on Saturday to the hour of prime on Monday. In 1041, a general 'truce of God' was accepted by the barons, first of Aquitaine, and then of all France, to last from the Wednesday evening of every week to the Monday morning following. This regulation was admitted by Edward the Confessor in England, in 1042, with some additions of great festivals and other days. It was confirmed by many councils, especially the Lateran Council of 1179. Philip Augustus of France introduced a new species of truce, termed the *quarantine*, by one of his ordinances. Under penalty of high treason, it restrained the family of an injured or murdered person from the commencement of hostilities until forty days after the commission of the act complained of. (For the general working of the system, see Milman, *Latin Christianity*, book viii. ch. vi.)

Truck. The small wooden cap at the extremity of a flag-staff, or at the mast-head. It is a small circular piece of wood with one or more pulleys for halyards to pass over.

Truck System. An arrangement by which an employer pays in kind or in goods, instead of in money. Such a method of paying wages is very early. Money was scarce in bygone times, and except for purchases from a distance was not needed. Even when a change took place in the value of money, and it became therefore accessible, it circulated but slowly, and tokens were freely stamped and issued by traders. This deficiency in money was long felt in the north of England, in which region the truck system naturally flourished.

If the employer were a benevolent and honest man, the supply of genuine commodities to his workmen in exchange for their labour, would be, as opposed to the high charges and frequent adulterations of small retail shops, a great boon. Clothing clubs, which take the money of labourers and expend it in large purchases at wholesale rates, are by no means an evil, but a great good, especially when the people are not pauperised by large grants under the name of interest. But the commercial relations of capitalist and factory operatives are not favourable to benevolence, and experience has unfortunately shown that the practice of the former was not even honest. The truck shops sold bad goods at exorbitant prices. In order to tie the factory hands to the masters, they encouraged a system of credit, and became as scandalous a public nuisance as roguery and helplessness could produce. The vile profits of the truck shop became a source of considerable and admitted revenue to the employers, and the workmen were paid at rates which, when compared with the real value of their earnings, were almost nominal.

The truck system was abolished by 1 & 2 Wm. IV. c. 37, not without opposition. It was urged against the action of parliament that it was undesirable to interfere with the freedom of trade; but those who use this righteous argument should take care that they are not striving to cover oppression and fraud under so sacred a term. Freedom does not mean the right of the strongest to oppress the helpless. The blemish of the Act was, that it was only made to extend to towns, and, like the Factory Children's Act, did not embrace within the provisions of its police the agricultural districts.

The Act of 1831 was preventive. But the most important means by which the workman can be supplied with goods of a trustworthy character, is by the establishment of co-operative stores of supply. The experiment has been tried successfully, and will have permanent effects. The system has several advantages. It secures the consumer from adulteration, for the consumers are the proprietors. It prevents the habit of credit in general articles of consumption, for no co-operative association can succeed which allows itself the risk of bad debts. [Co-operation.]

Trucks (akin to Gr. τροχός, *a wheel*). In Artillery, small thick round wheels of wood or iron. Also round blocks of wood, hollowed out at the centre, in which the feet of a gyn are placed, when the ground is bad.

True Bill. The formula by which the grand jury finds or approves a bill of indictment.

Truffle (Fr. truffe, Ital. trufa). Applied generally, the name Truffle (or Trubs) comprises all the *Fungi* which belong to the natural orders *Hypogæi* and *Tuberacei*. The Truffles, properly so called, belong, however, to the typical genera *Tuber*, and the closely allied genera *Chæromyces* and *Terfezia*.

The truffles of commerce all belong to the genus *Tuber*, of which several species are edible; the English Truffles belonging principally to *T. æstivum*, and the best French Truffles to *T. melanosporum*. These are black and warty externally, with the flesh variously marbled. The Piedmontese Truffles, on the contrary (which bear a high price, and are highly esteemed), are smooth, and within white more or less tinged with pink. Truffles are in this country sought for almost exclusively by dogs of a particular breed, but on the Continent sows are used for the same purpose, and they are raked up by persons who have a peculiar knack in recognising the spots where they are likely to grow.

All attempts have failed at cultivating them in the same way as mushrooms. In the South of France, indeed, truffles have been procured in woods by watering the ground, previously prepared, with water in which the parings had been steeped; but no one has yet been able to prepare spawn for sale in a form similar to that of mushroom-spawn. It is probable, however, that this will sooner or latter be accomplished.

Truffles require a calcareous soil, and in such soils they are, we believe, much more common than is usually supposed. They are by no means confined to beech-woods, but are found in England sometimes amongst oaks without any admixture of beech, and they do not dislike the neighbourhood of a few conifers. They have been seen sometimes so near the surface as to be cut off by the scythe when the grass is mown. Besides the edible truffles, which receive different names from collectors according to their degree of ripeness, there are several strongly scented or minute species, mostly with an even bark, which are either not esculent or too small to attract general notice.

The large white truffle belonging to the genus *Chæromyces* is too rare in England to be of much consequence, but it is a poor article of food. The African Truffle, belonging to the genus *Terfezia*, is a better esculent than the last, but not equal to the *Tuber æstivum*, though it appears of late to have attracted much notice in Algiers from its abundance; and numerous specimens have been also received from Mogadore. A species of *Hydnotrya* is sold abundantly in the market of Prague. The Red Truffle of the Bath market is a *Melanogaster*, and therefore belongs to *Hypogæi*, not *Tuberacei*. (Berkeley, *Treasury of Botany*.)

Trumpet (Ger. trompete, Ital. trumba, Swed. trumma, and thus akin to *drum*). In Acoustics, an instrument used for the purpose either of conveying articulate sounds to a great distance, or for applying to the ear, in order to collect the sonorous waves, and render sounds more distinct. In the former case the instrument is a *speaking-trumpet*; in the latter, a *hearing-trumpet*.

Speaking-trumpet.—The object of the speaking trumpet is to increase the intensity of speech, and transmit it to considerable distances in a particular direction. In order to obtain this effect, it is necessary that the aërial undulations which would disperse themselves in all directions be confined by the sides of the trumpet, and reflected so as to take, as nearly as possible, a direction parallel to the axis. This is accomplished by giving the trumpet such a form that its diameter becomes greater towards the extremity farthest from the mouth. A cylindrical or prismatic tube, of equal diameter throughout, assists powerfully in conveying sound from one extremity to the other, but contributes in no degree to give a direction to sound, or transmit it through free air.

The theoretical explanation of the effects of the speaking-trumpet is attended with considerable difficulty. Assuming that the reflection of sound takes place according to the laws of catoptrics, Lambert (*Berlin Memoirs for* 1763) shows that the best form of the instrument is a truncated cone, for the rays successively reflected from the interior surface of this figure make smaller angles with the axis after each successive reflexion. Cassegrain (*Journal des Savans*, tom. iii.) recommends the surface formed by the revolution of a hyperbola about its asymptote; and Kircher had previously proposed a truncated parabolic conoid, the mouth-piece occupying the focus. Some authors suppose that the trumpet should be formed of a very elastic material, in order to strengthen the sound by its vibrations. Others are of opinion that it should be without elasticity, to avoid the confusion that might be caused by the vibrations of the tube. Hassenfratz (*Journal de Physique*, tom. lvi.), who made a number of experiments on the power of the trumpet, by fixing a small watch in the mouth-piece, and observing the distance at which the beats ceased to be audible, found that the effects were precisely the same with a trumpet of tinned iron, whether used in its naked form, or tightly bound round with linen to prevent vibration, or when lined with woollen cloth, by which means reflexion was entirely prevented. It would appear, therefore, that neither the shape of the instrument, nor the material of which it is formed, is of much consequence. Leslie (*Experimental Inquiry into the Nature and Propagation of Heat*) supposes the effect of the trumpet to be owing to the more condensed and vigorous impulsion given to the air from its lateral flow being checked. 'The tube,' he observes, 'by its length and narrowness, detains the efflux of air, and has the same effect as if it diminished the volubility of that fluid,

or increased its density. The organs of articulation strike with concentrated force; and the pulses, so vigorously thus excited, are, from the reflected form of the aperture, finally enabled to escape, and to spread themselves along the atmosphere.' (P. 225.)

The invention of the speaking-trumpet is commonly ascribed to Sir Samuel Moreland, who, about the year 1670, proposed the best form of the speaking-trumpet as a question to the Royal Society.

Hearing-trumpet.—The hearing-trumpet, or ear-trumpet, may be considered as a reversed speaking-trumpet, with which it generally corresponds in form, though, for the sake of portability, it is often made curved or spiral. Lambert recommends the parabolic figure as the most advantageous; but, in order to give the greatest effect, the apex of the paraboloid must be cut off, and the mouth of a small tube inserted in the focus, to convey the sound concentrated at that point to the auditory organ. Various other forms are adopted in practice; and of late years, flexible Indian-rubber tubes have been brought into use, having a conical mouth-piece of ivory or silver at one extremity, and a small tube of like material to be applied to the ear. A trumpet of this kind may be used advantageously, not only for remedying the defects of the organ of hearing, but for assisting the observer to collect feeble and distant sounds. (Moreland *On the Speaking-Trumpet*, 1671; Chladni, *Traité des Sons*; Gehler, *Physikalisches Wörterbuch*, art. 'Hörrohr.')

TRUMPET. A musical wind instrument, usually made of brass, but sometimes of silver. This instrument formerly possessed but few notes; but in later times it has, by means of slides and keys, been vastly extended in its inflexions.

Trumpet Flower. A name applied to various large tubular flowers, as those of *Bignonia, Tecoma, Catalpa, Brunsfelsia, Solandra,* &c.

Trumpet Weed. The name of a sea-weed, *Ecklonia buccinalis,* belonging to the natural order *Laminariaceæ,* and very common and well known at the Cape of Good Hope. The stem is often twenty feet long, and is crowned at the top by a fan-shaped cluster of fronds, ten feet or more in length. The stem of this sea-weed, says Dr. Harvey, which is hollow in the upper portion, is when dried often used in the colony as a siphon, and by the native herdsmen is formed into a trumpet for collecting the cattle in the evening.

Truncate (Lat. truncatus, *maimed*). In Botany, this term is applied to bodies which terminate very abruptly, as if a piece had been cut off; as the leaf of the tulip-tree.

Trundle. In Mechanics, a pinion having its teeth formed of thick pins set in discs, otherwise called a *lantern wheel,* or *wallower.*

Trundle-head of a Capstan. The circular part at the top, with holes for the reception of the levers by which the apparatus is worked.

Trunk (Lat. truncus). In Architecture, the same as *shaft.* In the application of this word to a pedestal, it signifies the die, dado, or body of the pedestal.

TRUNK. In Entomology, this term signifies the intermediate section of the body which lies between the head and the abdomen.

Trunnions (Fr. trognon, *a core*). Short cylinders projecting from the sides of a piece of ordnance, by which it rests on its carriage or bed. They are generally about one calibre in diameter and length.

Truss (Fr. trousse, Dan. trosse). In Architecture, a framed assemblage of pieces of timber for the support of a principal beam or piece. [ROOF.]

TRUSS. On Shipboard, a rope confining the middle of a lower yard to the mast.

TRUSS. In Shipbuilding, timbers, or preferably iron plates, for giving a diagonal internal support to the side timbers or ribs.

TRUSS. In Surgery, an apparatus by which, in cases of rupture, the intestine is retained in the abdominal cavity. This is usually effected by the aid of a steel spring resting upon a small pad or cushion, which is kept in its place by a proper bandage.

Trussed Roof. In Architecture, one so constructed as to support the principal rafters and the beam at certain points where bending of the timber is likely to occur. [ROOF.]

Trust (Swed. trost, akin to troth, true, truce; Ger. treue, &c.). In Law, a term commonly used to designate any equitable right or interest as distinguished from a legal one: properly, that class of equitable rights supposed to be founded in the confidence placed by one party in another; the name *trustee* denoting the person in whom confidence is placed, and the term *cestui que trust,* signifying the person who trusts—in other words, the party who enjoys a beneficial interest in the objects of which the trustee has the legal property.

The origin of conveyances in trust may be traced to the fidei commissum of the Romans, which was a gift by will to a person capable of taking in trust for another who was incapable by the Roman law of taking such benefit, and whose claim under such gifts was for a long time precarious and merely fiduciary, but came at length to be recognised and enforced by law. With us, in the same manner, the original motive for the introduction of the fiduciary right, which was certainly borrowed from the Romans, was the wish to escape from the disabilities affecting certain persons, or bodies, or the liabilities attached to property in its direct and simple shape. Such was, in particular, the disability of corporations to purchase land; and on this account, as it is commonly said, the ecclesiastics, who were chiefly interested in this matter, introduced this new species of property, which was willingly recognised by the chancellors, who were usually ecclesiastics, and in other respects inclined to adopt the principles of the civil law. The clergy were, however, soon themselves deprived of the benefit of the invention, the

disability of corporations to take land being extended by statute to the new right so created. But there still remained many liabilities, arising from feudal tenure, incident to property at common law; such as, for instance, dower, escheat, wardship, restraint upon alienation by will, which it was desirable and possible either to evade by this mode of conveyance in trust, or to transfer to a quarter less likely to be affected by them: and there were also many modifications of property for the benefit of families, which could only be given in this manner. It is said, further, that there were less honest purposes, such as the defrauding bonâ fide purchasers by secret alienation, sought to be attained by the same means. For these, among other reasons, conveyances in trust were still resorted to; and the Court of Chancery, which had once, for whatever reason, originally recognised, continued to enforce them.

There were also two methods of creating a trust, or rather raising a use, without an actual conveyance: the one by agreement for money; the other by covenant under seal in consideration of near *relationship*.

The right so created was called indifferently a *trust* or *a use*; more commonly the latter, from the actual enjoyment of the rents and profits annexed to it in equity. Indeed, the benefit of the use or trust was, in the first instance, confined to this; but the cestuis que use, or parties beneficially interested, soon acquired the right of directing a conveyance by the holders of the legal estate, technically termed the *feoffees to uses*, and also of calling upon them to use the legal title in their defence in a court of common law. [USE.]

Several statutes were passed at different times, giving to the owner of the use or trust partial legal rights, and partially also subjecting interests of that sort to legal liabilities, before the celebrated statute, commonly called the Statute of Uses, which was passed in the twenty-seventh year of Henry VIII. The general object of this statute, as stated in the preamble, was to prevent those secret and fraudulent transfers occasioned by the separation of the real from the apparent ownership, and to restore those rights of the feudal lord, and of the crown, which had been in a great measure evaded by keeping the legal title (to which alone they attached) in a course of succession where it was unlikely to be forfeited by treason, and where it was less frequently subject, by descent to an infant heir, to the burden of wardship and relief. The general effect of the statute, as stated in the title, was the transferring or changing the use into possession, i. e. annexing to the use the legal right of possession, whereby the real owner would be made manifest to all, and the real ownership would become subject to all the liabilities incident to the legal title: in short, the distinction between equitable and legal rights would be abolished, and the adjudication on all questions of property, except in particular cases of fraud or accident, would be restored to the courts of common law.

The statute, however, was so worded as not to apply either to copyholds or leaseholds, nor indeed to personal property of any description, which at that time was little thought of; so that equitable rights in copyholds and personalty remained as before, merely equitable; and they arose again, very shortly afterwards, in every species of real property, it being held by the courts of common law that only such uses or trusts were executed and transferred into possession by the statute, as were raised or declared upon what was *before* the statute the legal seisin or estate; so that where a new legal estate taking effect as such by virtue of the statute was created or conveyed in trust, such trust-right, not being within the purview of the statute, and not being recognised by the courts of common law, was adopted and enforced in equity, for reasons altogether similar in kind to those which originally led to the introduction of uses.

Hence a new system of equitable rights grew up under the name of *trusts*, commensurate with the new system of legal rights or uses (for the use henceforth denoted the legal estate), created by the statute; and though some of the peculiar advantages of the old trust were, by the effect of the statute, transferred to the new legal ownership (such as the capability of modification for the benefit of different parties upon different events), and though the right of disposition by will was shortly afterwards extended to it by special statute, and though whatever advantages were still possessed by the *trust*, as a means of evading the burdens of tenure or the other liabilities now annexed to the *use*, were gradually removed either by the abolition of those burdens or the extension of those liabilities, trusts still continued and continue to be habitually resorted to for various purposes. These are, generally, either to protect the interests of married women and children, by placing in the hands of trustees for them the legal rights which they would be incapable of exercising; or to secure the rights of those in remainder, by severing from the usufruct of property for a life the power of disposing of the whole; or, lastly, the convenience of management, where many parties are interested in the same subject.

These observations can apply, at least with one or two exceptions, only to *express trusts*. An express trust supposes a legal transfer of the property actually completed, and a declaration in the same instrument, or having reference to the same instrument, of the trust upon which the property so transferred is to be held; and the ground upon which such trust rests is the express confidence that is placed in the trustee by the person who transfers the property to him, no consideration of money or blood between the trustee and those for whom he holds being required as an inducement for the interference of equity.

Trusts are most commonly raised by marriage settlements, or by will. [SETTLEMENT.] The usual trusts in the former case, as to real estate, are, in the first place, for securing to the wife payment of her pin money during marriage, and of her jointure after the husband's death; then for the raising the stipulated provisions for younger children, and also for providing for their maintenance during minority. Similar trusts, also, are commonly raised in wills, for the maintenance or advancement and portioning of children. In all such cases, the legal rights vested in the trustees most commonly remain in their hands, as a means only of compelling the person actually in possession to discharge those claims subject to which he holds his estate. But it is in regard to that sort of personal property, the title to which, or rather the power of conferring a title to which, is annexed to the possession, either from the nature of the thing itself, as in the case of money, or for reasons of public convenience, as in the case of stock in the funds (a class of property over which the holder, whether it be in trust or not, has by the regulations of the Bank absolute power of alienation) and other similar investments, such as shares in public companies, &c., that the utility of trusts is more particularly conspicuous. Whenever it is sought to create in any such property shifting or partial interests, nothing in such cases can secure future or contingent rights from the dishonesty of the tenant for life or partial owner but the intervention of trustees, in whose hands the whole legal interest, i.e. the whole power of alienation, resides; and though a similar danger is sometimes to be apprehended even at their hands, yet their number itself, and the discretion that may be exercised in their appointment, afford a greater security than is to be found in the integrity of a single individual.

Trustees are bound to act in strict accordance with the terms of their trust and the rules of the Court of Chancery, and will be made answerable for the consequences of any breach of trust, however innocent. They are liable not only for such sums as they actually have received, but for such also as they might, but for their wilful neglect or default, have received. Where there are several trustees, each is generally liable for his own acts and receipts only; but where all concur in empowering either one of themselves, or a third party, to do or receive that which he could not do or receive but by virtue of such authorisation, all are responsible for his acts and receipts under such joint authority. It is the duty of trustees, besides being faithful accountants, to apply and distribute rightly the property with which they are intrusted according to the various rights of the parties entitled to it; and they are liable for any misapplication, arising either from ignorance of facts which they ought to have known (i.e. might by common diligence have known), or from ignorance of the law in any case, and this although they may have acted in perfect good faith, and in reliance on the opinion of eminent legal advisers. The rights of trustees are confined to the reimbursement of their proper expenses out of the trust property. An express trust will not fail for the want of trustees; where none are nominated, the Court of Chancery will take upon itself the appointment.

In the case of *implied* or *resulting* trusts, the confidence is not expressed, but implied by courts of equity from the want of consideration or motive apparent in such cases, to give away the whole, or, as it may be, any part of the beneficial interest. Such trusts arise, for instance, upon the conveyance or transfer, by deed or will, of property, real or personal, upon some trust expressly declared, which does not exhaust the whole beneficial interest, or expressly upon trust, though no trust be declared: in the first of which cases, the surplus of the beneficial ownership, after satisfaction of the express purpose or trust, and in the second case, the whole of the ownership, results to the party making such conveyance or transfer.

Trysail. A small gaff sail of strong or storm canvas, set in bad weather.

Trythings. A division of counties into three parts, ascribed to Alfred. The word survives in the *Ridings* of Yorkshire.

Tsabaism. [SABAISM.]

Tscheffkinite. [TSCHEWKINITE.]

Tschermigite. A kind of ammonia-alum found in the Brown-coal formation of Tschermig in Bohemia.

Tschewkinite. An amorphous mineral of a velvet-black colour found near Miask in the Ilmen mountains and in the granite of the mountains of Siberia. It is composed chiefly of silica, titanic acid, protoxide of iron, lime, and the peroxides of cerium, lanthanium, and didymium. It is named after General Tschewkin.

Tschirnhausen's Transformation. Tschirnhausen's transformation of an algebraic equation has for its object to cause the disappearance of certain terms, and thus to facilitate its solution. This is accomplished by the introduction of a new unknown quantity y connected with the x of the given equation, say of the n^{th} degree, by the relation—

$$y = a_0 + a_1 x + a_2 x^2 \ldots + a_{n-1} x^{n-1},$$

where a_0, a_1 &c. are disposable coefficients. The elimination of x between this and the original equation leads to another in y of the n^{th} degree. Tschirnhausen published this method in the *Acta Eruditorum* of Leipzig in 1683, and it has since been employed by numerous writers. Prof. Cayley, in *Crelle's Journal*, vol. lviii. 1861, and in the *Phil. Trans.* 1862, has given the transformed equations for cubic, quartic, and quintic equations.

Tschudic or Chudic Languages. By this name are known those dialects of the Finnic class, which are spoken by the Lapps, Finns, and Goths, the other three branches being the Ugric, Bulgaric, and Permic. [TURANIAN LANGUAGES.]

Tsebaoth. [SABAOTH.]

Tube (Lat. tubus). In Artillery, a barrel of quill, paper, or metal, driven with mealed powder damped with methylated spirit, and having at the top a cup or head, varying in form and nature. In the British service all barrels of tubes are $\frac{2}{10}$ inch in diameter, and the vents in which they are placed $\frac{2}{8}$ inch. A hollow is made down the middle of the composition, so that its whole length may be ignited at once, and the large amount of gas thus generated in a small channel acquires sufficient force to fire the charge of powder in the gun.

There are several kinds of tubes in the service. The *common quill*, *Dutch*, and *common metal*, require to be fired by a portfire. The *cross-headed* or *detonating quill* is fired by a lock, the hammer striking a *crosspiece* or *snipe* containing detonating composition. The *copper friction*, for land service, and *quill friction* for naval service, are fired by a lanyard, the hook of which is fixed into a ring in a roughened friction bar, which is then pulled through detonating composition at the head of the tube. The *galvanic* and *electric* tuoes are fired by a galvanic battery or a magnet respectively. The latter, which is now used for the proof of guns, has an egg-shaped head, containing two copper wires, to the lower poles of which an explosive composition is pressed. The tube is connected with the magnet in a splinter-proof, by copper wires, and when the current circulates from the magnet, the spark ignites the explosive composition, and fires the tube.

TUBE. In Botany, the part of a monosepalous calyx, or monopetalous corolla, formed by the union of the edges of the sepals or petals. The same term is also applied to adhesions of stamens.

TUBE. A pipe or long hollow body. A tube is generally understood to signify a hollow cylinder, but the cylindrical form is not essential.

Tuber (Lat. *an excrescence*). In Botany, any roundish underground succulent stem, covered with buds, from which new plants or tubers are produced; as the potato. [PROPAGATION OF PLANTS.]

Tubercle (Lat. tuberculum, *a small tuber*). A material which, deposited in various parts of the body, destroys the tissues infested. When the lung is attacked, tubercular pulmonary consumption is the consequence; while, if the brain or the abdomen be affected, we have to fear the occurrence of water on the brain (hydrocephalus) or of disease of the mesenteric glands. Tubercle must be regarded as the result of a constitutional morbid state, either hereditary or acquired. The deposit of tubercle appears to be determined by several causes, such as mal-assimulation, bad diet, deficient ventilation, &c. The latter cause is regarded by a recent writer, Dr. MacCormac (*On Consumption*), as the great source of the evil. He undertakes to prove, (1) that rebreathed air induces tubercle, and (2) that no other known cause induces it.

Tubercle of Lower. An eminence in the right auricle of the heart where the two venæ cavæ meet; it was first described by Richard Lower, in 1665.

Tubercula Quadrigemina (Lat.). Four white oval tubercles in the brain, two of which are situated on each side, over the orifice of the third ventricle and the aqueduct of Silvius. The old anatomists called them *nates* and *testes*.

Tubercule (Lat. tuberculum). In Botany, a term applied to simple roots which acquire a succulent condition, become reservoirs of vegetable food, and serve for propagation in consequence of being terminated by a bud. A little tuber.

Tuberose. The fragrant-blossomed Liliaceous plant, called by botanists *Polianthes tuberosa*.

Tubicoles (Lat. tubus, *a tube*, and colo, *I inhabit*). The name of an order of Anellidans, comprehending those which live in tubes, and which are Cephalobranchiate; also the name of a family of Lamellibranchiate Acephalous Molluscs, including those which have a tubular calcareous sheath in addition to the two shelly valves.

Tubicorns (Lat. tubus, and cornu, *a horn*). The name of a family of the order of Ruminants comprehending those in which the horns are composed of a horny axis covered with a horny sheath.

Tubifers (Lat. tubus, and fero, *I bear*). The name given by Lamarck to an order of the class *Polypi*, comprising those which are united upon a common substance fixed at the base, and the surface of which is wholly or partially covered with retractile hollow tubes.

Tübingen School. A name applied to the theological writers belonging to the university of Tübingen, whose chief characteristic is their opposition to all mystical or euêmeristic interpretations of the various books of the Old or New Testament. Among the most prominent writers of this school are Strauss, Baur, and Zeller. Of these, the first is the great antagonistic of the euêmerist or rationalistic method of Dr. Paulus, who professed to account for all miracles as exaggerated or distorted accounts of ordinary events. This method he displaced by the theory of the mythus, as furnishing the materials for narratives which have grown up round a nucleus which he allows to be historical; but although the writers of this school may on this theory of myths differ somewhat in opinion, they all agree in excluding sentiment and imagination from all attempts to determine the character of the early Christian church or the teaching of its Founder. (Mackay, *The Tübingen School and its Antecedents*.)

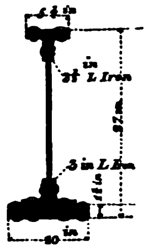
Tubipores (Lat. tubus, and porus, Gr. πόρος, *a passage* or *pore*). The name of a family of Zoophytes, comprehending those in which the animals are isolated and contained in elongated cylindrical calcareous cells, attached by their base, and strengthened by cross bars at definite distances.

Tubular Bridge. A bridge formed of a great tube or hollow beam, through the centre of which a roadway or railway passes. The most remarkable bridge of this kind was designed by Mr. Robert Stephenson for carrying the Chester and Holyhead Railway over the Menai Straits, for although the bridge since carried across the St. Lawrence is of much greater total length, the width of each of its constituent spans is less. The Menai bridge consists of two rectangular tubes of wrought-iron plates riveted together; one tube being for the accommodation of the up line of rails, and the other for the accommodation of the down line of rails. A pier erected upon a rock in the middle of the straits divides each tube into two spans of 462 feet each, and there is also at each end a smaller tube of 230 feet span to serve as approaches to the bridge. These several tubes are joined together so as to form one long tube for each line of rails of the total length of 1,524 feet.

The thickness of the central pier is 45 feet, of the side piers 32 feet each, and the tube projects 17 feet 6 inches over the masonry at each end. The bridge contains 9,480 tons of wrought iron, 1,988 tons of cast iron, and 1,500,000 cubic feet of masonry. The total expense of its construction was 601,860*l.*, of which the iron work cost 443,160*l.* and the masonry 158,700*l.* It was commenced on the 10th of August, 1847, was finished on the 5th of March, 1850, and was opened for traffic on the 18th of March, 1850. A similar bridge of one length of tube and of a somewhat smaller span had been previously erected, under Mr. Stephenson's direction, over the river Conway on the same line of railway. This bridge was opened for traffic in 1848.

History of Tubular Bridges.—On the occasion of an entertainment given at the opening of the Conway bridge in 1848, Mr. Stephenson gave an account of the circumstances which had led to the conception of the plan of carrying a railway over a river or chasm by employing as a bridge a hollow beam or tunnel constructed of iron plates. About six or seven years before he had been called upon to construct a bridge on the Northern and Eastern Railway at Ware under certain limitations imposed by Act of Parliament which rendered bridges of the ordinary forms inapplicable; and he thereupon resolved to employ malleable iron beams, by the aid of which a cellular platform was made which answered the exigencies of the occasion. In this cellular platform, however, there does not appear to have been much novelty of conception, for it was merely an arrangement of beams of the ordinary form of railway girders, and the only peculiarity of these beams was that they were made of wrought iron instead of cast iron as had been the previous practice. They were proportioned moreover in the same manner as cast-iron beams—as will be seen by fig. 1, which is a cross section of one of them—whereas it is now known that malleable iron beams should have the top and bottom flanges of about the same dimensions. However, from the suggestions of this structure, the idea of a tubular bridge first arose in Mr. Stephenson's mind, and in his original conception he appears to have contemplated the use of elliptical or cylindrical tubes supported by chains. Mr. Stephenson's engagements did not permit him to work out this idea, or to put it into such a practical form that he would have himself had confidence in carrying it into execution. He therefore delegated this task to his assistants, who, taking up the idea where Mr. Stephenson had left it, pursued the enquiry with great ardour and sagacity until they finally brought the idea into the form in which it was carried into practical effect.

Fig. 1.



Long before this time, however, a form of bridge much more nearly resembling that finally adopted for crossing the Menai Straits than Mr. Stephenson's cellular platform at Ware, or even than his subsequent conception of an oval or cylindrical tube supported by chains, had been successfully introduced in Switzerland; but the bridges which had been erected upon this plan, instead of being made of wrought iron, were constructed of timber. The first of these bridges appears to have been erected over the Rhine at Schaffhausen by Jean Ulrich Grubenmann in 1757. It consisted of two spans—the one of 170 feet, and the other of 193 feet. In 1778 another bridge of a similar construction was built by the same person over the Limmat at Wettingen. The span of this bridge was 390 feet. Fig. 2 is a section of this bridge at the ends, and fig. 3 is a section at the centre. It will be apparent from these figures that this bridge is composed of a platform for the roadway, two side frames of carpentry, and a roof, so that it in fact constitutes a great hollow timber beam of a nearly rectangular form. These bridges were both burnt by the French in 1799, after having remained in constant use, the one for forty-two years and the other for twenty-one years. Armies, artillery, and heavy weights, had passed over them in

Fig. 2.

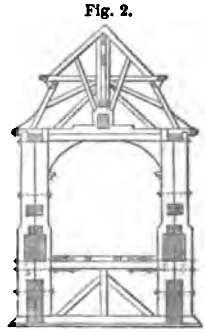
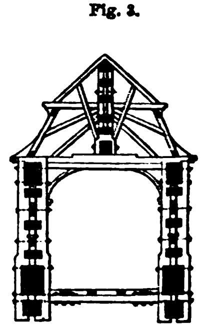


Fig. 3.



safety, and they appear to have perfectly fulfilled the purpose for which they were designed. Each of the side frames was raised into its place by means of powerful screw jacks resting on piles.

Subsequently to this time, lattice timber bridges came into considerable use in America. These bridges consist of two or more great frames of carpentry formed of planks or timbers crossing one another diagonally, and bolted at top and bottom to shelf pieces. The lower shelf piece carries a platform which forms the roadway, and in some cases the top is also covered with lattice work so as to convert the bridge into a hollow lattice beam. In a few cases these lattice bridges were formed of iron, and in Boston there is an elliptical tubular lattice bridge of iron of 120 feet span. This bridge had been in use a few years before the construction of that cellular platform at Ware which Mr. Stephenson says first suggested to his mind the idea of a tubular bridge. Lattice bridges formed of bars of iron have of late years come into use in this country, and have been very largely employed in India and other countries possessing large rivers, over which railways have to be carried. [VIADUCT.] An excellent example of a lattice bridge is the one carried across the Thames at Blackfriars for the London, Chatham, and Dover Railway, and such bridges are now generally preferred to tubular bridges formed of iron plates.

In entering upon the consideration of the best mode of carrying out Mr. Stephenson's idea, it occurred to Mr. Fairbairn, upon whom this responsibility now devolved, that the most judicious course would be to institute a series of experiments to determine the breaking weight of beams or tubes of different forms, with the view of ascertaining what form of tube would reconcile the greatest amount of strength with the least quantity of material, and also what load a tube of a given form and of given dimensions could with safety sustain: these experiments were accordingly instituted, and they speedily furnished information of great practical importance. It was very soon found that oval and cylindrical tubes were not of so eligible a form as rectangular ones; and it was further found that in rectangular tubes the strength should be chiefly concentrated at the top and bottom, and in nearly equal proportions. It also occurred to Mr. Fairbairn that it would be advisable to make the top and bottom of the tube of a cellular form, which would obviate the necessity of using plates of such a thickness as could not be so securely riveted. This construction, it was anticipated, would also impart greater stiffness to the structure, and render the top less liable to buckle up when a heavy strain was applied.

Experiments to determine the best Form of Tube.—The first experiments were made upon cylindrical tubes formed of iron plates, riveted together like the chimney of a steamboat. The tube experimented upon was laid horizontally between two supports, and a small hole was cut in the centre of its lower side to enable a rod of iron to pass through; from this rod of iron the weights employed to ascertain the strength were suspended; around the hole a collar was riveted so as to impart as much strength to that part of the tube as before the perforation had been made, and a cushion of hard wood 8 inches square was fitted to the interior of the tube above the perforation. Through this piece of wood the rod which carried the weights ascended, and a cutter passing through the end of the rod rested on a square plate of iron superimposed upon the wood, so that from the wooden cushion the whole weight depended. Many of the tubes gave way by tearing at the riveting of the plates; but some also broke from the compression at the top. The more important results of these experiments are exhibited in the following tables:—

Strength of Cylindrical Tubes used as Beams.

Number of Experiment	1	2	3	4	5	6	7	8	9
External diameter	12·18 in.	12 in.	12·4 in.	18·26 in.	17·68 in.	18·18 in.	24 in.	24·3 in.	24·2 in.
Length between supports	17 ft.	17 ft.	15 ft. 7½ in.	23 ft. 5 in.	23 ft. 5 in.	23 ft. 5 in.	31 ft. 3¾ in.	31 ft. 5¾ in.	31 ft. 3½ in.
Thickness of plates	0·0408 in.	0·037 in.	0·131 in.	0·0582 in.	0·0631 in.	0·1190 in.	0·954 in.	0·119 in.	0·98 in.
Weight of tube	102 lbs.	107 lbs.	392 lbs.	334 lbs.	346 lbs.	777 lbs.	1,007 lbs.	1,385 lbs.	1,085 lbs.
Greatest deflection	0·39 in.	0·65 in.	1·20 in.	0·56 in.	0·74 in.	1·19 in.	0·63 in.	0·93 in.	0·72 in.
Breaking weight	3,010 lbs.	2,704 lbs.	11,440 lbs.	6,400 lbs.	6,400 lbs.	14,240 lbs.	9,760 lbs.	14,240 lbs.	10,880 lbs.
Broke by compression or extension	Compression	Compression	Extension	Extension at rivets	Extension at rivets	Extension at rivets	Extension at rivets	Extension at rivets	Extension at rivets

The thickness of the plates in these experiments was ascertained by cutting a portion of the plate into small pieces and screwing these pieces together in a vice. The collective thickness was then accurately measured, which divided by the number of pieces gave the thickness of each. It appears probable that the whole of the tubes would have been broken by compression, but for the weakening of the bottom caused by the rivet holes, which generally produced fracture by extension in that part.

The ends of the tubes where they rested upon the supports had to be kept in shape by circular pieces of wood inserted into them. When these pieces of wood were withdrawn, the ends were flattened horizontally. At the same time the centre of the tube was flattened vertically by the action of the weight hanging at the under side, and in looking endways at the tube the two sections made a species of cross—the ends forming the horizontal part of the cross, and the centre the vertical part.

The following are the results of the experiments made with elliptical tubes:—

Strength of Elliptical Tubes used as Beams.

Number of Experiment	1	2	3	4	5	6
Major axis	14·625 in.	21·66 in.	21·25 in.	15 in.	12 in.	13 in.
Minor axis	9·25 in.	13·50 in.	14·123 in.	9·75 in.	7·5 in.	8 in.
Length between supports	17 ft.	24 ft.	24 ft.	17 ft. 6 in.	18 ft. 6 in.	18 ft. 6 in.
Thickness of plates	0·0416 in.	0·1310 in.	0·0688 in.	0·143 in.	0·0733 in.	0·064 in.
Weight of tube	109 lbs.	708 lbs.	357 lbs.	374 lbs.	252 lbs.	267 lbs.
Greatest deflection	0·62 in.	1·35 in.	0·45 in.	1·45 in.	0·95 in.	1·14 in.
Breaking weight	2,100 lbs.	17,076 lbs.	7,714 lbs.	15,490 lbs.	6,867 lbs.	8,812 lbs.
Broke by compression or extension	Both	Extension	Compression	Extension	Compression	Compression

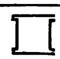
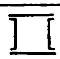
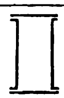
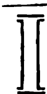
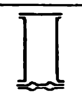
Nos. 5 and 6 of the foregoing experiments were not made with simple elliptical tubes, but the tube employed in No. 5 was an elliptical tube with a fin at the top (fig. 4), and the tube employed in No. 6 was more of a rectangular form with a fin at the top (fig. 5).

Fig. 4. Fig. 5.


These top fins were not found to operate advantageously, as they were thrown into compression before the strain came on the top of the tube itself, and the strength was thus overcome in detail.

The most important of the experiments, however, are those upon rectangular tubes, the results of which are as follows:—

Strength of Rectangular Tubes used as Beams.

No. of Experiment	1	2	3	4	5	6	7	8
Form of Cross Section								
Top flange, inches	12 by ·075	12 by ·757	12 by ·142	12 by ·149	12 by ·269	6 by ·260	10 by ·260	2 Plates ·115 each
Bottom flange, in.	12 by ·0743	12 by ·142	12 by ·0757	12 by ·269	12 by ·149	10 by ·260	6 by ·260	·180
Sides, inches	9·6 by ·0743	9·6 by ·0757	9·6 by ·0757	18·25 by 0·594	18·25 by ·0594	15 by ·131	15 by ·131	15·40 by 0·70
Length between supports	17 ft. 6 in.	17 ft. 6 in.	17 ft. 6 in.	17 ft. 6 in.	17 ft. 6 in.	24 ft.	24 ft.	19 ft.
Weight of tube	202 lbs.	255 lbs.	255 lbs.	317 lbs.	317 lbs.	788 lbs.	788 lbs	500 lbs.
Greatest deflection	1·12 in.	0·94 in.	1·88 in.	1·03 in.	1·13 in.	2·66 in.	2·58 in.	1·59 in.
Breaking weight	5,738 lbs.	5,788 lbs.	7,148 lbs.	6,812 lbs.	12,188 lbs.	17,600 lbs.	15,920 lbs.	22,469 lbs.
Broke by compression or extension	Compression	Compression	Extension at rivets	Compression	Compression	Compression	. .	Compression

These experiments, with a few others of a similar character, which it would be needless to recapitulate, having been concluded, Mr. Fairbairn directed his attention to the determination of the proportions which it would be proper to adopt for the tubular bridges which it was proposed to construct. It was made very clear from the experiments that the rectangular form was the best, and that the strength should be concentrated chiefly at the top and bottom of the tube, where the extending and compressing forces would act with greatest energy, and where they must be met. The proportion of the sectional area of the top to that of the bottom to give the maximum strength, was also found to be as 5 to 3 in the case of thin rectangular tubes. It was also made clear that the strength of a tubular beam would be increased if the buckling or crumpling up of the top side could be prevented; and it was known, from previous experiments of Mr. Hodgkinson upon cast-iron pillars, that a given quantity of metal would better resist compression if disposed in a tubular form than if disposed in any other form. Hence it occurred to Mr. Fairbairn, that the compressing strain upon the top of the tube would be more effectually counteracted by disposing the metal in the form of longitudinal tubes than by disposing it in the form of a flat plate. The tube with the corrugated top, tested in the eighth experiment upon rectangular tubes, was made in pursuance of this idea, but eventually it was determined to form the top of the bridge of a series of parallel rectangular tubes or cells, chiefly because that form was more convenient in construction, and better admitted of painting and repairs. The bottom of the tube it was considered advisable to make in the same fashion; and these points being settled, a model tube was constructed, which was nearly identical with one of the tubes of the intended bridge in everything but size. The model tube was 78 feet long, and 75 feet between the supports; 4 feet $6\frac{3}{4}$ inches deep at the middle, and 4 feet $\frac{3}{4}$ inch deep at the ends. It was 2 feet 8 inches wide in the body; but the cellular top was somewhat wider, being 2 feet $11\frac{1}{2}$ inches wide, and the bottom, which was not cellular, but consisted of a flat plate, was of the same width as the top. The cellular top was composed of six longitudinal channels, formed by seven vertical plates $6\frac{1}{4}$ inches deep running longitudinally from end to end of the tube, and having a plate above and another below them extending through the whole length and breadth of the top. The thickness of the plate of the bottom of the model tube was ·156 inches, of the sides ·099 inches, and of the top ·147 inches. The sectional area of the top was 24·024 square inches, of the sides 9 square inches, and of the bottom 8·8 square inches. The weight of the tube was

4·86 tons. Its ultimate deflection was 4·375 inches, and its breaking weight $35\frac{1}{2}$ tons. The tube gave way by tearing asunder at the bottom.

The top plates of the tube having been made a little thicker than was intended, two strips of plate 20 feet long, $6\frac{1}{2}$ inches wide, $\frac{5}{16}$ of an inch thick, and weighing about 4 cwt., were riveted along the bottom of the tube at the centre part. The ultimate deflection then became 4·11 inches, and the breaking weight 43·3 tons. In this experiment the tube got out of shape and collapsed. To obviate this evil for the future, vertical ribs of angle iron were riveted along the sides of the tube internally, at distances of 2 feet apart, and the tube having been repaired, was again subjected to experiment. The ultimate deflection was now found to be 5·68 inches, and the breaking weight 56·3 tons. As, however, in this experiment the fracture occurred, not at the centre of the tube, but at some distance to one side, where the plates were weak, a final experiment was made with the plates decreasing in thickness from the middle according to the proper law. The tube then broke by compression of the cellular top with a weight of $86\frac{1}{4}$ tons.

Mode of Determining the Dimensions proper for the Menai and Conway Bridges.—The strength of any beam larger or smaller than a beam of any given size, but which is increased or diminished proportionally, varies as the *square* of the alteration of its linear dimensions, or more nearly as the 1·9th power in the case of tubular beams, whereas the weight varies as the cube of any linear dimension. A beam, therefore, of twice the length, depth, and thickness of any given beam, will be about four times as strong and eight times as heavy. Taking the weight of the model tube upon which the foregoing experiments were made at 6 tons, the distance between the supports at 75 feet, and the breaking weight of the tube at 60 tons, Mr. Fairbairn calculated that a tube of 400 feet span, such as was intended to carry the railway over the Conway river, would bear a load of 1,704 tons exclusive of its own weight. For since the span of 400 feet is 5·33 times greater than that of the model tube, then $5·33^2 \times 60 =$ 1,704 tons, and the weight of the tube will be $5·33^3 \times 6 = 906$ tons. Now, a given load distributed equally over a beam produces nearly the same strain upon it as half the load applied at its centre, or more correctly the ratio is as 5 to 8. Taking the half of 906 or 453 from 1,704, we have 1,251 tons as the actual load which Mr. Fairbairn considered that the tube would bear exclusive of its own weight.

Mode of Computation by Hodgkinson's Formula for Cast-iron Beams.—Some years before the formation of the Britannia and Conway bridges, Mr. Hodgkinson had ascertained the form of cast-iron beams which gave the greatest strength with the least material; and by the formula derived by Mr. Hodgkinson from these experiments, Mr. Fairbairn concluded that the model tube would bear about 20 tons if it were of cast iron. But it actually bore 56·3 tons in one of the experiments of which the result was not the best; and introducing this correction into the formula, it appeared that a tube six times larger than the model tube, and therefore of 450 feet span, 27 feet deep, and with 460·8 square inches of sectional area of iron at the bottom, would bear 2,018 tons exclusive of the weight of the tube itself. The results obtained by calculating the strengths as the squares, and the weights as the cubes of the dimensions, do not differ materially from the foregoing; and Mr. Stephenson calculated that a tube of 462 feet span, 31 feet deep, and 460 square inches of area at the bottom, would bear 2,469 tons; thus, supposing the tube to weigh 1,200 tons, the breaking weight, when the load was applied at the middle, would be 1,869 tons, exclusive of the weight of the tube itself. Now, a tube which will carry 1,869 tons at the centre, exclusive of its own weight, will, he reckoned, carry about twice this amount, or 3,738 tons, equally distributed over it, exclusive of its own weight; and taking the maximum load to which the bridge would be subjected at one ton per lineal foot, it followed that the bridge, when thus proportioned, would bear eight times the load that could ever be put upon it. One of the tubes of the Conway bridge when completed was tested in the same manner as the model tube, by placing weights upon it and observing the deflections. The result was found to confirm the accuracy of the deductions derived from the experiments upon the model tube. The law followed by the deflections appeared to show that the tube would sustain a load of 2,200 tons equally distributed over it, and exclusive of its own weight, before it broke, and that the ultimate deflection would be 30 inches.

Mr. Hodgkinson's Experiments.— Besides the experiments made by Mr. Fairbairn, a number of experiments upon tubular beams was made by Mr. Hodgkinson, at Mr. Stephenson's desire, and from these experiments results were obtained of great interest in a scientific point of view. Mr. Hodgkinson found that the strength of tubes to resist compression varied greatly with the thickness of the metal of which they were composed. Thus, when the plates composing a tube, compressed in the manner of a pillar, were ·525, ·272, and ·124 inch, the resistances per square inch of section were 19·17, 14·47, and 7·47 tons respectively. Mr. Hodgkinson also found that the power of plates to resist compression varied as the cube, or, more nearly, as the 2·878 power of their thickness. He further found that long-continued impact upon a tubular beam of small size, producing a deflection of less than one-fifth of what would be required to injure the tube by pressure, was completely destructive of the riveting. In large bridges, however, the inertia of the mass will, by resisting the effect of impact, prevent any such injurious effect from taking place.

He also determined, experimentally, that the strength of similar tubular beams was as the 1·9th power of their linear dimensions. Mr. Hodgkinson further made a series of experiments to ascertain if the thickness of the plates of a tubular bridge might be diminished towards the ends, as indicated by theory, and he found that such was the case. The thickness of the plates of the top, bottom, and sides, at any point, was therefore made in the proportion of the rectangle of the segments into which the distance between the supports of the tube was divided at that point, the tube itself being of uniform dimensions throughout; but at and near the supports the thickness was half that of the middle. A further experiment was made to ascertain how far it might be advantageous to stiffen tubular beams with cast iron applied at the top, and it was found that 10 square inches area of cross section of cast iron at the top of the beam balanced 21 square inches of cross section of malleable iron at the bottom of the beam, proving that the cast iron would resist compression more efficiently than the wrought. These investigations, however, though highly important, did not materially influence the configuration of the Conway and Menai bridges, the proportions of which were mainly settled by Mr. Fairbairn from his experiments upon the model tube already described. Experiments were also made, both by Mr. Fairbairn and Mr. Hodgkinson, to determine the strength of tubular beams when laid upon their sides. The purpose of this investigation was to determine the lateral strength to resist storms blowing on the side of the tube, and it was found that the proportions and strengths proper for resisting the vertical strains would also give a lateral strength more than sufficient to withstand any storm to which the tube could be exposed.

Comparative Strains caused by Stationary and Moving Loads.—In proportioning iron beams or girders to bear any given load, the prevailing practice among engineers has heretofore been to give a strength adequate to carry three times the load, if the load be stationary, and twice that strength, or a strength adequate to carry six times the load, if the load be a moving one. When the Conway and Menai bridges were constructed, the precise effect produced upon iron bridges by shifting pressures, vibrations, and concussions consequent upon the passage of a railway train, was by no means accurately known; but since that time those relations have been investigated by a commission appointed for the purpose, and it was one of their functions to ascertain what increase of the statical pressure upon an iron beam or bridge would occasion the same strain as a given velocity of the load. It is clear that, this relation once determined, the statical pressure is all that has henceforth to be considered, and the question of the strength proper for all kinds of constructions is consequently narrowed to the determination of the strength necessary to withstand a certain statical strain, which is greater in an ascertained proportion than that due to the intended maximum load.

Effect of Momentum on the Deflection of a Beam.—If a load be placed upon any long or slender beam propped up in the middle, and the prop be suddenly withdrawn so as to allow deflection to take place, it is clear that the deflection must be greater than if the load had been gradually applied. For the momentum of the weight, and also of the beam itself, falling through the space through which it has been deflected, has necessarily to be counteracted by the elasticity of the beam; and the beam will therefore be bent momentarily to a greater extent than that which is due to the load, and after a few vibrations up and down it will finally settle at that point of deflection which the load properly occasions. It is obvious that such a beam must be strong enough to sustain not merely the pressure due to the load, but also the accession of pressure due to the counteracted momentum of the load, and of the beam itself; and this increased strain is produced in the case of all beams to which a deflecting weight is applied, but is most material in those in which a large and rapid deflection takes place. A rapid deflection increases the amount of the deflection as well as the amount of the strain, as is seen in the cylinder cover of a Cornish pumping-engine, into which the steam is suddenly admitted, and in which the momentum of the particles of the metal put into motion increases the deflection to an extent which the mere pressure of the steam could not produce.

Effect of Deflection on the Amount and Position of the Strain.—If a railway train moving at a high rate of speed be made to descend a steep declivity, the pressure of the wheels upon the rails will obviously be diminished; and if the motion of the train be supposed to be very rapid and the declivity very great, the wheels will leave the rails altogether, and the train will advance after the fashion of a projectile. In like manner, if a rapid train ascends a steep acclivity, the pressure of the wheels upon the rails will be increased. Now, a beam bent by a passing train forms both a falling and rising plane, and on the first half of the beam the strain will be less than that which is due to the load, and on the second half of the beam the strain will be greater than that which is due to the load. The maximum strain therefore, and consequently the maximum deflection, will not be at the centre of the beam, but at a point somewhere between the middle and one end. In order to remedy this inconvenience, the beams of a railway bridge should be made with a slight rise in the centre, so as to form a straight line when deflected by a passing train.

Law of the increased Strain consequent upon Deflection.—The momentum of any moving body being proportional to the square of its velocity, it follows that in the case of a railway train deflected either sideways or upwards by a curve or incline, the strain will be proportioned to

the square of the amount of motion in a new direction given in any specified time; or with any given velocity of the train the strain will be proportional to the square of the amount of the deflection which takes place from a perpendicular or horizontal plane in any given distance along the line.

Effect of the Inertia of Beams.—The mass of matter in a beam first resists deflection by its inertia, and then promotes deflection by its momentum; but whether in practical cases increased mass without reference to strength or weight will, upon the whole, increase or diminish deflection, will very much depend upon the magnitude of the mass, relatively with the magnitude of the deflecting pressure and the rapidity with which that pressure is applied and removed. Thus, if a force or weight be very suddenly applied to the middle of a ponderous beam and then be as suddenly withdrawn, the inertia of the beam will, as in the case of a collision of bodies, tend to resist the force, and thus obviate deflection to a considerable extent; but if the pressure be so long continued as to produce the amount of deflection due to the force, the effect of the inertia in that case will be to increase the deflection. The mass must, under such circumstances, move through a space equal to the deflection, a momentum having been thus acquired which will afterwards expend itself in increasing the deflection. By far the severest strains, however, to which railway structures are habitually exposed arise from the jerks and concussions caused by the imperfect junctions of the rails at the ends, or other similar irregularities of surface, and a large amount of inertia in a beam will enable it to withstand such shocks much better than it could otherwise do. A large inertia compels the train to deviate from the horizontal plane to an extent answerable to the difference of weight of the striking and stricken bodies, so that if the bridge be heavy, it will, under such circumstances, be less deflected, and consequently will suffer a less serious strain.

Law of the Elasticity of Iron Beams.—A bar of iron is usually regarded as a very stiff spiral spring, and it is supposed that it will be compressed or extended equally by equal increments of pressure. This law, however, though nearly true for malleable iron, is not true for cast iron. The compressions and extensions of a bar of cast iron one inch square, and of any length, were found by Mr. Hodgkinson to be represented by the following formulæ :—

For the extension, $w = 13934040 \frac{e}{l} - 290743200 \frac{e^2}{l}$,

For the compression, $w = 12931560 \frac{d}{l} - 522979200 \frac{d^2}{l^2}$.

Here w is the weight in pounds acting upon the bar, e the extension, d the compression in inches, and l the length of the bar in inches. Iron beams alternately deflected and released will be broken in time with a much less strain than that which is necessary to produce speedy fracture. Thus it has been found experimentally, that cast-iron beams deflected by a revolving cam to only half the extent due to their breaking weight will, in no case, withstand 4,000 successive deflections; but 4,000 successive deflections through one-third of the distance due to their breaking weight may be incurred without visible injury. Looking, however, to the various jolts, vibrations, and concussions to which railway structures are exposed, it does not appear that even a strength answering to six times the breaking weight gives an adequate margin for safety in the case of cast-iron beams.

Proportions to be observed in the Construction of Tubular Bridges.—The sectional area of the bottom of a tubular bridge of wrought-iron plates should be to the sectional area of the top as 11 to 12. The breaking weight is then found by multiplying the total area by the depth, by a constant (80), and dividing by the length. The depth of tubular beams of 150 feet span should be about $\frac{1}{13}$ of the span, and the depth of tubular beams of 300 feet span should be about $\frac{1}{15}$ of the span. These rules are empirical, but they are a near approximation to the most approved practice of the present time.

Description of the Britannia and Conway Tubular Bridges.—Having now indicated the manner in which the proportions and configuration of these bridges were arrived at, and having further pointed out the considerations which should influence the design of all railway bridges composed of iron beams, whatever be the subordinate features of their construction, it will be proper to describe briefly the more important features of the Britannia and Conway bridges as they at present stand. The annexed

Fig. 6.

figure represents a portion of one of the tubes seen in perspective. There are two tubes in each bridge, one for the accommodation of the up line, and the other for the accommodation

of the down line. Each tube is rectangular, formed of plates of iron riveted together, and with ribs to support the sides, like the ribs of a ship. The most remarkable feature of the construction, however, is the cellular top and bottom. In all beams which have to be loaded in the centre, it is proper to concentrate the strength as much as possible upon the edges of the beam, or at the top and bottom; and in the case of these bridges this is done by building upon the top and bottom a number of square pipes or pillars joined laterally together and running from end to end of the bridge. The upper pipes sustain a force of compression, the lower of extension; and the function of the sides of the tube is merely to keep these combinations for meeting compression and extension in their proper places. The sectional area of the top and bottom of the tubes may easily be computed by taking the width of each tube, which is 14 feet 8 inches, and the thickness of the plates; but in the model tube, which gave the best results, the sectional area of the top was to that of the bottom as 24 to 22, and this is the proportion commonly employed. There are eight cells or pipes composing the cellular top, each 1 foot 9 inches square. The plates composing the top of the Britannia bridge are $\frac{12}{16}$ at the middle of the bridge, and $\frac{10}{16}$ at the ends of the bridge. The ends of the plates are carefully abutted together, and strips of iron are riveted over the joints. The bottom is composed of six cells or pipes, each 2 feet 4 inches by 1 foot 9 inches; and the upper and lower platforms, by the introduction of partitions between which the cells are constituted, consist each of a double thickness of plates so arranged that the end of each plate comes to the centre of the other, as shown in the accompanying figure. A small plate covers each joint, and as it was important not to weaken the bottom of the tube by the rivet holes running across it, the rivets are arranged in longitudinal rows, each a considerable distance from the other, and they act as cogs or steady pins in keeping the plates together. By this expedient the longitudinal cohesion of the bottom is better maintained; and the strength of each tube approximates to what it would be if formed out of a solid piece of iron, instead of being built up of riveted plates. The thickness of the plates forming the upper and lower platforms of the bottom is $\frac{9}{16}$ at the middle of the tube, and $\frac{7}{16}$ at the ends. The vertical plates are $\frac{9}{16}$ at the middle, and $\frac{8}{16}$ at the ends. The sides of the tube are $\frac{8}{16}$ at the middle of the bridge, increasing to $\frac{10}{16}$ where the bridge rests upon the piers; for as the ends of the tube have to sustain the whole weight, they require to be made very strong and stiff to retain them in shape. To impart increased stiffness at the ends of the tubes, strong cast-iron frames are introduced within them, and an arrangement of rollers is provided beneath the ends of the tubes to enable the metal of the tubes to expand or contract with changes of temperature.

Fig. 7.

The tubes of each bridge were built in the same manner as an iron ship, adjacent to the place where they had to be erected. A wooden platform or quay was erected upon the shore, upon which a tube was built, and stone supports were subsequently erected at the ends, upon which the tube when completed was made to rest. The timber platform was then cleared away so as to enable a number of boats or pontoons to be floated beneath the tube, and these rising with the tide lifted the tube. The floating mass was then drawn by ropes across the stream, and the ends of the tubes were rested in shelves left in the masonry of the piers, by which the tube had to be sustained. On the tops of the piers hydraulic presses were set, from which chains descended to the ends of the tube, and by putting these hydraulic presses into operation the tube was raised up a small distance, and so soon as it was raised sufficiently above the shelf the intervening space was built up. Another lift was then taken, and so on, the masonry following up the tube as it ascended, until it reached the level of the top of the piers. In the Britannia bridge there are four spans; and the tubes of each span are joined together at the ends, so as to form one long tube for each line of railway. The effect of thus joining the ends of the tubes is virtually to diminish the span, for the tube takes a contrary flexure where it passes over the piers, and if a line be drawn down the side of the tube where these contrary flexures meet, it will be found that the tube might be cut through that line without weakening it at all.

Chepstow and Saltash Tubular Bridges.—Tubular bridges of a construction very different from that of the Conway and Britannia bridges have been erected by Mr. Brunel, for carrying the South Wales Railway over the river Wye, at Chepstow, and also at Saltash. These bridges have a nearer resemblance to a suspension bridge than to a hollow beam: but instead of the heads of the towers being held back by chains, as is usual in suspension bridges, they are kept asunder by cylindrical struts of wrought iron, and rods descend from the tops of the towers, which are also of iron, to support the platform of the bridge. [VIADUCT.] The limits of this article, however, leave no room for any detailed description of these and other tubular bridges which have been constructed since the Conway and Menai bridges were projected. (For further information on the subject, see Mr. Fairbairn's *Account of the Construction of the Britannia and Conway Tubular Bridges*, and the *Report of the Commission appointed to inquire into the Application of Iron in Railway Structures*; Jeaffreson and Pole, *Life of Robert Stephenson*, vol. ii.

Tubular Surface. In Geometry, the envelope of a sphere of constant radius whose

centre describes a given curve—the *axis of the tube*. These surfaces have been most instructively treated by Monge in his *Application de l'Analyse à la Géométrie*. Two successive generating spheres intersect in a circle, of the same diameter as the sphere, whose plane is normal to the axis. The surface itself may be considered as the *locus* of this circle, which by Monge is termed the *characteristic*. [CHARACTERISTIC OF AN ENVELOPE.] The successive characteristics by their intersection form an *edge of regression* or *cuspidal edge* on the surface. If $x=f(a)$, $y=\phi(a)$, $z=\psi(a)$ be the equations of the axis, and a be the radius of the generating sphere, the equation of the latter in one of its positions, individualised by the parameter a, will be

$$F(x,y,z,a)=[x-f(a)]^2+[y-\phi(a)]^2 \\ +[z-\psi(a)]^2-a^2=0,$$

and the equation of the tubular surface will result from the elimination of a between the equations $F=0$ and $\frac{dF}{da}=0$, which two equations, in fact, represent the *characteristic* corresponding to the value of a. The equations of the *cuspidal edge* are obtained by eliminating a between $F=0$, $\frac{dF}{da}=0$, and $\frac{d^2F}{da^2}=0$. For further details the reader is referred to Monge's work.

Tubularia. The name of a genus of Corallines with simple or branched horny tubes, from the extremities of which the polypes are protruded: these have two rows of tentacles, of which the external is expanded in a radiated manner, the internal one being raised into a tuft.

Tubulibranchians. The name of an order of hermaphrodite gastropodous Molluscs, comprehending those which have the shell in the form of a more or less irregular tube in which the branchiæ are lodged.

Tubulicoles. *Polypes à Tuyaux.* A name applied by Cuvier to a family of Polypes, including those which inhabit tubes of which the axis is traversed by the gelatinous flesh, and which are open at the summits or sides to give passage to the digestive sacs and prehensile mouths of the polypes.

Tubuliflore (Lat. tubus, and flos, *a flower*). One of the three large suborders into which De Candolle divides the *Compositæ*. It comprises the *Corymbiferæ* and *Cynarocephalæ* of Jussieu, including those Composite plants which have all or at least the central florets of each head regular and tubular.

Tucan. [RAMPHASTOS.]

Tuesday. In the Calendar, the third day of the week, named after the god Tuisco; whence the astronomical symbol is the same as that for the planet Mars. [TYR.]

Tuesite. An amorphous mineral of a bluish or milk-white colour, and closely allied to Halloysite, China Clay, and Lithomarge. The name is derived from *Tuesa*, the Latin name for the river Tweed, in the New Red Sandstone of whose banks the mineral is found.

Tufa (Ital. tufo, *porous ground*). A name applied in Italy to certain porous loose rocks, sometimes consisting chiefly of calcareous matter deposited from water containing much carbonate of lime in solution, and sometimes of fine powdery volcanic dust cemented more or less completely by the infiltration of water, but generally loose and spongy. This dust consists of material erupted from volcanoes, and under the microscope has sometimes been found to contain large quantities of the silicious cases of infusoria.

The first-named variety is called *calcareous tufa*, the last-named *volcanic tufa* or *tuff.*

Volcanic Tufa is the material under which Pompeii was buried. Similar materials have been deposited in places where there are no other indications of volcanic action, and occur among rocks of all ages.

Calcareous Tufa when consolidated passes into Travertine.

Tuff. [TUFA.]

Tug. A ship used for the purpose of towing other vessels.

Tugendbund (Ger. *union of virtue*). A patriotic association formed in Prussia after the treaty of Tilsit in 1807. Its object was to prepare the people of that country by moral instruction and discipline for better times. It was abolished at the instigation of the French; but its spirit survived, and it had great effect in promoting the national war against Napoleon in 1813.

Tuisco. [TYR.]

Tulip-tree. The common name for the North American *Liriodendron tulipifera.*

Tulip-wood. The striped rose-coloured wood of *Physocalymma floribunda.*

Tulipa (Pers. thoulyban, *a turban*). A genus of *Liliaceæ*, consisting entirely of bulbous plants. *T. Gesneriana*, the Tulip of gardens, has been a favourite object of the florist's care for three centuries. Gesner, who first made it known by a botanical description and figure, saw it in A.D. 1559 at Augsburg, the seeds having been brought from the Levant. It was at that time known in Italy under the name of *tulipa*, given to it on account of its resembling a turban, *tulbent*. In the middle of the seventeenth century, Tulips became the object of an unprecedented trade, by which their price rose above that of the most precious metals. The high prices paid for bulbs, amounting in some instances to 2,500 and even 4,600 florins, did not, however, represent the estimated value of a root, since these large sums often changed hands without any transfer of property. Bulbs were bought and sold without being seen, and even without being in existence. The tulip is still extensively cultivated, there being many hundreds of named varieties.

Tullius, Servius. [SERVIUS TULLIUS.]

Tumble Home. The term describing the falling or bending inwards of the upper timbers

of the ship's side. It is the function of the beams to counteract this tendency.

Tumbrel (Fr. tombereau). A covered cart employed to convey ammunition, the tools of miners, pioneers, &c. The term is now almost obsolete.

Tumuli. [Barrows.]

Tun (A.-Sax. tunna). A measure of capacity. The English tun contains 252 gallons, or 4 hogsheads. [Ton.]

Tune (Ital. tuono, Fr. ton, Gr. τόνος, from τείνω, *to stretch*, akin to *thunder*). In Music, a tune signifies an air or melody. In other words, it is a certain succession of different single sounds arranged according to art. The word also refers to accuracy of intonation; a voice or instrument is said to be *in tune* when all its notes are correctly intoned, and *out of tune* when they are intoned incorrectly. *To tune an instrument* is to adjust its strings or other sounding elements so as to give correct intonation, or make it play in tune.

Tungstates. Compounds of *tungstic acid*. Muslin and similar textures imbued with a solution of tungstate of soda are to a great extent rendered incombustible.

Tungsten (Swed. tung sten, *heavy stone*). The ores of this metal are the native tungstate of lime, and the tungstate of iron and manganese; the latter mineral is known under the name of *Wolfram*. Tungsten is a white, hard, and brittle metal, very difficult of fusion, and having the high specific gravity of 17·4. Heated to redness in the open air, it burns into the *peroxide*, or tungstic acid. The atomic weight of tungsten is 92, and the tungstic acid consists of 1 atom of metal and 3 atoms of oxygen ($8 \times 3 = 24$), and is represented by the equivalent 116. This metal is sometimes called *Wolframium*. It is generally represented by the symbol W.

It forms two oxides: binoxide WO_2 and teroxide or anhydrous tungstic acid WO_3; an oxychloride WO_2Cl; two sulphides WS_2 and WS_3; and two phosphides W_3P_2 and W_4P. [Wolfram.]

Tunic (Lat. tunica). A garment worn by the ancient Romans of both sexes, under the Toga and next to the skin. It was generally of wool, of a white colour, and it reached below the knee. The senators wore their tunics with a broad stripe of purple sewn on the breast; the equites had narrow stripes: hence the epithets *laticlavii* and *angusticlavii*, applied respectively to these orders.

Tunicaries (Lat. tunica). The name of a class of Acephalous Molluscs, comprehending those in which the exterior covering is uncalcified, soft, and elastic: it is equivalent to the *Ascidies* of Savigny, and the *Acephales sans Coquilles* of Cuvier.

The following is the modern classification:—

Order: *Saccobranchiata*.

Fam.: Botryllidæ, Clavellinæ, Ascidiadæ, Peloniadæ, Pyrosomidæ.

Order: *Tæniobranchiata*.

Fam.: Salpidæ.

Tunkers. [Dunkers.]

Tunnel (Ger.; Fr. tonnelle). A horizontal perforation in the earth, usually made to conduct a railway or canal through a mountain or other elevated ground, or under a river or other tract of water which cannot conveniently be bridged. One of the most interesting works of this kind is the tunnel carried under the Thames, to connect the lower parts of London lying on each side of the river with one another by a convenient roadway, without involving the necessity of building a bridge, which in that spot would interfere with the navigation of the river. Tunnels of much greater length and difficulty have, however, since been constructed; and it is now proposed to connect the French and English systems of railway by a tunnel carried beneath the British Channel. In the English railways, there is on an average one mile of tunnel for every 124 miles of railway. Tunnels are generally lined with brick or stone, but sometimes the sides and top consist of the naked rock, and in such cases there is occasionally considerable leakage in wet weather through cracks in the roof.

The first task in the construction of a tunnel is to fix the vertical plane which it shall follow, and this is done by the aid of a transit instrument, usually about thirty feet focal length, set in a raised wooden structure or observatory placed on the highest ground in the centre of the length, and so far raised above the surface that the view may not be obstructed by the earth raised through the working shafts. Tunnels are almost universally straight, but with a sufficient declivity towards each end to facilitate drainage, crooked tunnels being not only more difficult to construct, but a source of danger in working the line, from the inability of the engine-driver to see ahead. The centre line of the tunnel having been carefully ranged, the next procedure is to sink trial shafts, which are sometimes made sufficiently large to be used as working shafts, and through these shafts and through the ends of the tunnel the excavated earth is removed. When the shafts are completed, the *heading* or *adit* is commenced, which may be described as a small square tunnel, the sides of which are supported by stout poles and boards, and which is afterwards enlarged to the dimensions which it is required that the tunnel shall have. The top of the heading is usually placed so much above the intended soffit of the arch of the tunnel as to admit the proposed thicknesses of brickwork and of the crown bars, packing and poling boards, together with an allowance of several inches for the settlement of the timber, which is sure to take place when more of the excavation is made, and before the brickwork can be inserted to take the weight. When the heading is driven, it is widened at the top along one side, to form a shelf on which a crown bar may be laid lengthways. Other bars are then similarly introduced, which are strutted from the ground and from one another, and poling boards overlapping one another are then

introduced behind the bars, the whole forming a short length of rough wooden tunnel within which the brick tunnel is built up as the work advances. The length of tunnel built at a time is usually about twelve feet.

The most remarkable tunnel yet undertaken is the tunnel through Mont Cenis, as it is usually called, although it is in fact several miles from that pass. It is intended to connect the French and Italian systems of railways. This tunnel is 7½ miles long, through rock. At Modane, on the French side, it is 25 feet 3¼ inches wide at the base, and 26 feet 2¾ inches wide at the broadest part, by 24 feet 7 inches high, the arch being a semicircle nearly. At Bardonnèche, on the Italian side, the height is increased 11¾ inches. At the French end, the tunnel is lined with stone, and at the Italian end the sides are of stone and the arch of brick. From the French end to the middle the gradient is 1 in 45½. The other end slopes from the centre downward with a declivity of 1 in 2,000 to enable the water to run off. When the tunnel is completed, it is expected that there will be a constant draft of air through it from north to south. The tunnelling is effected by blasting the rock with gunpowder, but the holes in which the gunpowder is deposited are bored by a machine, driven by compressed air, which, in twenty minutes, pierces a hole 1¼ inch diameter and 3 feet deep, which would have taken two miners two hours to bore. The machine consists of two main parts: the first a cylinder for propelling the borer against the rock, and the second a rotatory engine for working the valve of the striking cylinder, for turning the borer on its axis at each successive stroke, and for advancing or retiring the striking cylinder as occasion requires. A movable framework is arranged for carrying eleven such machines, any one of which may be worked at any angle—allowing the free action of each in a gallery ten feet square. Each machine gives 250 blows per minute. The pressure of air on the piston is 216 lbs. per square inch, and the length of the stroke varies from 2 inches to 7½ inches. The cost of each machine is about 80*l.* The average advance of the tunnel at the beginning was at the rate of four or five feet per day, but latterly the rate of progress was greater. The speed of tunnelling by these machines is about three times greater than by tunnelling in the old way, but the cost per foot forward is also somewhat greater. The ventilation of the workings is maintained by the escape of compressed air from the machines. The air is compressed by two machines at the outside of the tunnel, of which one operates on the hydraulic ram principle, and the other is a compressing pump. The tunnelling is estimated to cost 210*l.* per mètre. The tunnel of Mont Cenis is a mile in depth below the top of the mountain.

For a history of the Thames Tunnel, the reader is referred to Beamish's *Life of Sir M. I. Brunel*.

A boring machine for tunnels, with an outside cutter and central hole for powder, was made at Boston, U.S., and used in the Hoosie tunnel in 1852. Gay has a patent for the same thing, and other patents for similar contrivances have since been taken out. A good account of the mode of constructing ordinary tunnels is given in Simms' work on *Practical Tunnelling*.

Tunny. [THYNNUS.]

Tupa (its Chilian name). A genus of *Lobeliaceæ*, consisting of tall herbaceous plants or undershrubs, with unbranched stems, alternate lance-shaped leaves, and many-flowered leafy racemes. They are natives of Peru, Chili, and the West Indies. *T. Feuillei* yields an acrid poison in Chili, where the root is chewed to relieve the pain of decaying teeth. So acrid is this plant, that, according to Feuillée, even the odour of the flowers will cause excessive vomiting, and if taken internally, or even applied to the skin, violent inflammation and pain are produced, sometimes resulting in death.

Tupelo or **Tupelo-tree.** An American name for *Nyssa*.

Turanian Languages. In Philology, a name applied to languages which have reached the second stage of grammatical developement. In the first or radical stage, every word or part of a word is felt to express its own radical meaning, as in Chinese, which has no formal distinctions between a noun, a verb, an adjective, an adverb, or a preposition. As soon as the word used as a suffix loses its etymological meaning, and becomes a mere sign of derivation or of case, the language enters into the second or agglutinate stage which marks the dialects of the Turanian family. This family comprises by far the largest number of languages. The languages of the third or inflexional stage, spoken by Aryan nations, have all unquestionably passed through the agglutinate stage, but the component parts have in these so coalesced that it becomes in numberless instances very difficult to distinguish the root from the modifying element. Such a grammatical system would be wholly useless for the needs of a nomadic population, which requires that their language should be intelligible to many who may have only the slightest intercourse with each other. 'It requires tradition, society, and literature to maintain words and forms which can no longer be analysed at once. Such words would seldom spring up in nomadic languages, or, if they did, would die away with each generation.' Thus the Sanscrit or even the Latin inflexion of the verb as-mi, sum, *to be* [LANGUAGE], might be intelligible to nomads, because, for the most part, it preserves the root in a form in which it may easily be distinguished from the pronominal suffix; but the English inflexion of the same verb would convey to them no meaning.

The idea which a Turanian 'connects with a plural is that of a noun followed by a syllable indicative of plurality: a passive is with him a verb followed by a syllable expressive of suffering, or eating, or going.' Hence these

languages are especially liable to the changes produced by dialectical regeneration, until the tribes attain a political organisation. The dialects then assume a traditional form, as is the case with the Hungarian, Finnish, Tamil, Telugu, &c.

The Turanian family of languages consists of two great divisions—the *northern* and *southern*.

'The northern is sometimes called the *Ural-Altaic* or *Ugro-Tataric*, and it is divided into five sections: the *Tungusic*, *Mongolic*, *Turkic*, *Finnic*, and *Samoyedic*.

'The southern, which occupies the south of Asia, is divided into four classes: the *Tamalic*, or the languages of the Dekhan; the Bhotîya, or the languages of Tibet and Bhotan; the *Taic*, or the dialects of Siam; and the *Malaic*, or the Malay and Polynesian dialects.' (Max Müller, *Lectures on Language*, first series, viii.)

The Basque language, still spoken in the Spanish and French Pyrenees, is a form of speech which in grammatical construction resembles the Turanian family of languages, while it is surrounded by inflexional dialects, with none of which it exhibits the slightest affinity; but the evidence of inscriptions on coins or monuments, together with the names of cities, rivers, and mountains, seems to prove that the Escuara, or Basque, now spoken only by the insignificant tribes who call themselves Escualdunac, was once the language of a race spread over the whole Spanish peninsula; but the language itself further points to a time when the only languages spoken throughout Europe (so far as it was inhabited) belonged to the class of which specimens are still seen in the Basque and Finnic dialects. (Michel, 'Le Pays Basque,' *Edin. Rev.* April 1864, p. 373; *Quart. Rev.* April 1866, p. 419 &c.) [Agglutinate Languages.]

Turanira Wood. The timber of the Bastard Bully-tree of Guiana, which is probably a species of *Mimusops*.

Turban (Arab.). The usual head-dress of the Turks, Persians, and most other Eastern nations. It varies in form in different nations, and in different classes of the same nation. It consists of two parts: a quilted cap, without brim, fitted to the head; and a sash, scarf, or shawl, usually of cotton or linen, wound about the cap, and sometimes hanging down the neck. The sultan's turban contains three heron's feathers, and is ornamented with diamonds.

Turbine (Lat. turbo, *anything that turns round*). A species of horizontal water wheel, formed with inclined vanes resembling those of a windmill or smoke jack, and put into revolution by a stream of water passing through it. There are various forms of turbine, all constructed on the same general principle, but differing in the details. A good turbine will give a performance of 80 per cent. of the theoretical power of the water, being about the same as that which is obtained from a good overshot water wheel.

By a patent of 1849, Mr. Ruthven applied this principle, in a reversed sort of way, i.e. as a centrifugal pump, to the propulsion of ships; and after some minor successes, the British Admiralty launched the iron-clad gunboat Waterwitch, of 778 tons, in 1866, to test the efficacy of the system. A large turbine is rotated by powerful machinery. Centrifugal force drives the water contained in it at the rate of 300 tons a minute, out of nozzles in the side of the ship, while water rushes through valves in the bottom, to supply the place of that which is expelled. The nozzles open backwards or forwards by a double valve, motion being imparted to the vessel by the direct action of the water driven out. The nozzles are amidships; and as they can be worked independently, the steering power is very great, even without reference to the rudder. Thus far, the Waterwitch is but an experiment; the results, however, of several trials show that this mode of propulsion is as economical at the least as screw or paddle, while there are some other points in its favour, as, for instance, the extraordinary facility for pumping water out of the ship.

Turbo (Lat.). The name of a Linnæan genus of the *Vermes Testacea*, characterised by having a shell of a regular turbinated form with an entire and rounded mouth. The species grouped together by this specific character form a family of pectinibranchiate Gastropods in the system of Cuvier, which is united by later conchologists with the family Trochidæ.

Turbot (Fr.). The best, and, excepting the halibut, largest of our flat fishes: it is the type of the subgenus *Rhombus* of Cuvier.

Turdus (Lat.). The Linnæan generic name of the passerine birds which have the beak conical, sub-compressed, and arched, but not terminally hooked, nor so deeply notched at the margin as in the shrikes. They are frugivorous as well as feeders on insects, worms, and molluscs. The genus includes our blackbirds and thrushes, with the mocking-birds of North America, and various exotic birds now ranked as subgenera.

Turf (A.-Sax. tyrf). The surface of grass lands, of a smooth and uniform texture, covered with pasture grass. The term is also sometimes applied to Peat cut out of bog.

Turgite. A compact reddish-brown mineral, composed chiefly of hydrated peroxide of iron, found in the Turginsk copper mines in the Ural.

Turk's-cap. The name applied to *Melocactus communis*; also to *Lilium Martagon*.

Turkey. [Meleagris.]

Turkey Red. A fine and durable red dyed upon calico and woollen cloth; the colouring matter used in its production is madder, but the process for producing it in perfection is tedious and complicated. (Bancroft *On Permanent Colours*.)

Turlupins (a word of which no satisfactory derivation has been found: Ducange, *Glossary*). In French Ecclesiastical History, one of the numerous popular by-names by

which the sectaries of the fourteenth century, *the* precursors of the Reformation, were distinguished: called elsewhere BEGHARDS, BEGUINS, LOLLARDS, PICARDS, &c.

Turma (Lat.). In the Roman legion, a company of horse, ten of which formed the whole cavalry attached to each legion. Each *turma* consisted of thirty horsemen, divided into three decades or decuries, representing severally the three equestrian tribes, Ramnenses, Titienses, and LUCERES; and each commanded by a *decurio* with an *optio* or lieutenant.

Turmeric (Ital. turtumeglio). A medicinal and tinctorial substance obtained from the root of *Curcuma longa*. It forms one of the chief ingredients in the preparation of Indian curry-stuff or curry-powder, to which it imparts its yellowish hue.

Turn (A.-Sax. tyrnan, Ital. torno, probably akin to Gr. τόρνος). In Music, a grace thus marked ~; indicating that the note above it, one degree higher, must be struck before it shortly, then passed quickly through the note itself and *turned* from the note a degree below into the note itself, over which the mark is placed.

Turn-table. A large circular plate of metal set on a railway on the level of the ground, so that a locomotive or railway carriage may run upon it, and by then turning the plate round, the carriage may be delivered on to another line of rails than that from which it was received. [RAILROADS.]

Turnbull's Blue. A modification of *Prussian Blue*. [PRUSSIAN BLUE.]

Turner's Cerate. This is the *calamine ointment* of the *Pharmacopœia*. The modern zinc ointment prepared with oxide of zinc and hog's lard is a good substitute for it: it is a mild drying ointment.

Turner's Yellow. The fused oxichloride of lead, in fine powder: it is the basis of a yellow oil colour used in coach-painting: it is also called *patent yellow*, and *Cassel yellow*.

Turneraceæ (Turnera, one of the genera). A small order of hypogynous Exogens, consisting of tropical herbs or undershrubs, chiefly American or African, with alternate leaves, and yellowish or blue axillary flowers. They agree with *Passifloraceæ*, *Homaliaceæ*, and some others in their petals alternating with the lobes of a campanulate or tubular calyx, and in their one-celled ovary with three parietal placentas. They are chiefly remarkable for their forked styles.

Turnerite. A yellow or brown mineral containing alumina, lime, magnesia, and a small quantity of iron-oxide. It is found at Mount Sorel in Dauphiny, and was named after Mr. Turner, in whose cabinet it was first noticed.

Turning Lathe. An instrument for rotating hard materials, such as wood or iron, round a horizontal axis, to the end that a fixed cutting edge, such as a chisel, may be applied to them, their external surface being thus made to assume a true circular form. The turning lathe is an instrument of great antiquity, and is nearly allied in its character to the potter's wheel, only that in that instrument the axis is vertical. In the East, turning lathes do not usually give a continuous rotation to the objects placed in them, but the objects are first rotated in one direction and then in the other, by means of a bow, the string of which is passed once or twice round the material to be turned, the bow being moved backward and forward by one hand while the chisel is held by the other, aided usually by the toe. The introduction of the treadle, and crank and fly-wheel, to give continuous motion to the spindle of the turning lathe, was a valuable improvement, the author of which is not known; but it was in imitation of this arrangement that Watt introduced the crank and fly-wheel into the steam engine. Turning lathes are now made, for many purposes, of very great size, and large lathes are almost invariably driven by a steam engine. Such lathes are also set upon an iron bed, upon which the rest which holds the cutting tool may be drawn along gradually by a screw; and as the sliding surfaces are made very true, the article placed in the lathe is turned with corresponding accuracy. If the cutting point is drawn forward in a straight line, the article in the lathe will have a truly cylindrical form; but if the cutting point be made to move round a vertical axis passing through the horizontal axis of the lathe, the article will assume a globular form; or if the cutting point be gradually drawn back while it is at the same time moved onwards, and be again restored to its former depth, the article, instead of being truly cylindrical, will be bellied in the middle. The *chuck* of a lathe is a plate which may be screwed upon the rotating spindle, and to which objects requiring to be turned may be fixed. But the chuck may be so constructed, that instead of simply rotating with the spindle, it will move in and out at the same time. In this case it is called an *eccentric chuck*, and by its aid such figures may be traced on the surface of the work as are seen on the backs of watches. [ROSE ENGINE.]

Turnip (A.-Sax. næpe, Lat. napus). A well-known garden vegetable and agricultural root-crop, furnished by the many varieties of *Brassica Rapa*. The Swedish Turnip is the *Brassica campestris rutabaga*.

Turnip-fly. As different insects prey, in the larva state, upon the leaves of the growing turnip, the most destructive, and consequently the most important and interesting of these, will be noticed under the present head. They are the turnip-flea, as it may be called from its power of agile leaping (*Haltica nemorum*), and the turnip-fly (*Athalia centifolia*). The turnip-flea belongs to a genus (*Haltica*) of minute Coleopterous insects, of the section *Tetramera*, and family *Galerucidæ*; in which genus the species are all remarkable for the large size of the femora or thighs of the hindmost pair of legs. The species in question does not exceed the twelfth of an inch in length; it is of an oval form, with the elytra of a greenish tinge, each ornamented with a broad longitudinal stripe of a pale brimstone colour; but there

are other species of the same genus, perhaps equally destructive, and not characterised by the longitudinal elytral bands. The perfect insect shelters itself in the rough uncultivated margins of fields, feeding upon the hedge-weeds; and appears to be ready at any time, provided the weather be warm, to commence the work of destruction on the young turnip shoots. Late sowing of the turnip seed does not therefore obviate the attacks of the *Haltica*. The first precaution obviously is to clear away all the weeds in the neighbourhood of the turnip grounds that may afford food or shelter to the little enemy. When the turnip-flea has made its appearance in the crop, the ground should be dusted with quicklime, and this should be repeated as often as rain or wind beats it off, and the flea reappears. The other enemy to the turnip (*Athalia centifolia*) belongs to the order *Hymenoptera*, and family *Tenthredinidæ*, or saw-flies.

Turnsol. [Litmus.]

Turnsole. A purple dye-drug, the inspissated juice of *Crozophora tinctoria*.

Turpentine (Gr. τερέβινθος). A resinous exudation, which flows from incisions made in the stem of trees of the Pine family. Thus, Boston Turpentine is an American Turpentine, obtained from *Pinus palustris* and *P. tæda*; Bordeaux Turpentine is a resin obtained from *Pinus Pinaster*; Strasburg Turpentine is a resin obtained from *Abies pectinata*; and Venetian Turpentine is an oleo-resin obtained from *Abies Larix*, the common Larch. Chio, Scio, or Cyprus Turpentine comes from a different source; it is a limpid fragrant balsamic resin yielded by *Pistacia Terebinthus*.

Turpeth, Turpith, or Turbith Mineral. The yellow basic sulphate of mercury ($3HgO,SO_3$), so called from its yellow colour, which resembles that of the root of the *Ipomæa* or *Convolvulus Turpethum*.

Turquois. A bluish-green stone much used in jewellery. It is an amorphous form of hydrated phosphate of alumina. The finest kinds of Turquois are obtained from Persia and Arabia; but it is also found in Saxony. The name, according to Jameson, originated in the circumstance of the first specimens having been brought from Turkey.

For a full account of this stone (the Oriental Turquois), and the Occidental (Bone Turquois or Odontolite), see Bristow's *Glossary of Mineralogy*.

Turret Ship. A species of iron-clad war vessel, in which the guns are carried in one or more iron turrets, which may be rotated either by hand winches or by a steam engine, so that the guns may be fired in any required direction. There are two varieties of turret ship, of which the earliest and best is that which was invented by Captain John Ericsson of New York. The other variety—which in many of its features resembles the plan of Ericsson—is known as the system of Captain Cowper Coles, and this system has been adopted to some extent in the British navy, while the American navy has adopted the system of Ericsson, usually called the *Monitor system*, from the Monitor, the name of the first vessel of this kind that was constructed. The American Monitors have this great feature of superiority over Captain Coles' turret ships, that they are so provided with artificial ventilation that all the orifices in the deck may be hermetically sealed except those provided for the admission of the air which enters through high shot-proof trunks, which trunks, while admitting the air, exclude the water. They may thus be made much thicker in the sides than other vessels which depend for their ventilation upon open hatches or gratings, as the sides may without risk be made very low. Usually only a portion of the saving effected in the weight by lowering the side is expended in increasing the thickness of the armour, the residue being expended in increasing the weight of the gun and the power of the engine. But inasmuch as in the Monitor system the area of target is made a minimum, the thickness of armour or the power of engine and gun may be made a maximum with any size of vessel. Much doubt was at one time entertained by some, whether vessels with the low sides of the Monitors would be safe at sea. But such doubts have now been extinguished by experience; and it is plain, that as the Monitor construction combines the greatest power of offence with the greatest power of resistance, it constitutes the most formidable species of war vessel known at the present day.

History of Turret Ships.—The first design of a turret ship was produced by Ericsson, who, on September 26, 1854, forwarded to the Emperor Napoleon a drawing of an iron-clad screw vessel with a revolving iron-clad cupola or turret protecting a heavy gun. The turret was placed in the centre of the ship, and was hung on a central spindle turned by a steam engine, as in the Monitors, while the rudder and screw were protected, as in the Monitors, by projections of the deck. But although the design was not produced until 1854, during the Crimean war, Ericsson had been giving the subject his attention since 1826. In a letter to the *Times*, dated April 5, 1862, Captain Coles says the idea of building impregnable vessels first occurred to him in the year 1855, and that towards the latter part of that year he had a rough model of such a vessel made by the carpenter of the Stromboli. But Captain Coles' first idea was limited to the construction of a raft, with a gun placed upon it and protected by a shield. Under this arrangement, the raft had to be moved in order to point the gun. This crude idea was submitted to the Admiralty, but met with no encouragement there. Subsequently, Mr. Brunel suggested to him the expediency of placing the gun and its protecting shield upon a turn-table. In March 1859, Captain Coles produced drawings of a shield fitted with turntables; and in December 1860, he published drawings of his gun-shield and revolving plat-

form in *Blackwood's Magazine*. These shields are each composed of a heavy framework of timber, covered by 4½-inch armour plates, and each of them forms the frustum of a cone 15 feet in diameter in the largest part, and 6½ feet high. Within this cramped conical apartment, two breech-loading Armstrong guns are mounted, which it is proposed to fire with a service charge of 12 lbs. of powder. It was with conical cupolas on this plan that Captain Coles first proposed to fit the Royal Sovereign. But meanwhile the success of the Monitor in America caused the sloping shields to be abandoned, and the Ericsson form of turret to be substituted, retaining, however, the turntable rollers, which involve several features of serious disadvantage. What these are, it will now be proper to explain.

Difference between Ericsson's and Coles' Turret Ships.—In Ericsson's turret ships—or Monitors, as they are usually termed—two heavy guns are placed in a central turret, though in some cases two turrets are employed, each carrying two guns. In the Puritan and Dictator class of Monitor, the iron on the sides is 10½ inches thick, backed by over 3 feet of oak, and the turret is of iron 15 inches thick. Nevertheless, the Dictator is a vessel of much less displacement than the Bellerophon in the English navy; and if her displacement were made the same, then the thickness of the iron of the turret could be increased to 24 inches, and the thickness of the side armour and the power of the engine could also be augmented. In the Royal Sovereign the thickness of the side armour is only 5½ inches. In Ericsson's Monitors, the turret is attached to the vessel by means of the central spindle, and the bottom edge of the turret rests water-tight upon a metal ring let into the deck. In Coles' vessels, the turret passes through a great hole in the upper deck, and rests on rollers set on the deck beneath. A large annular opening is left round to permit its free rotation, which is accomplished by men working winch handles below the deck, and as it is difficult to make this great orifice water-tight, and as there is no artificial ventilation for the avoidance of open stoke-hole hatches, the sides of the ship must be made as high as those of any ordinary vessel, while, as the area to be protected is large, the armour has to be correspondingly thin to enable the vessel to carry it. If, moreover, the turret, from the impact of heavy shot, should cease to be quite round, the gearing employed to turn it will no longer work; or if shot and shell be broken up on the face of the turret, fragments will be projected into the annular space between the turret and the deck, which will jam and hinder its rotation. The donkey engines which rotate the turret of the Dictator, exert a force of 70,000 lbs. applied at its circumference; and the movement of a man's finger, acting upon the valve of the engines, will suffice to rotate the turret in either direction.

Many vessels have been constructed in America on the plan of the Monitor, and, having been subjected to the severest tests in actual war, have been found to be seaworthy, shot-proof, and efficient in every respect. Most of the Monitor vessels are fitted with 15-inch cast-iron guns; but the Puritan is fitted with 20-inch cast-iron guns, and the American government now contemplates the construction of cast-iron guns of 25-inch bore, and throwing a shot of a ton weight. Ericsson's 13-inch wrought-iron gun is built up of longitudinal bars welded together, and over this barrel washers of plate iron three-eighths of an inch thick are forced by hydrostatic pressure. This gun has sent a ball to a distance of 5 miles with a charge of 70 lbs. of powder, and it is reckoned that it could not be burst even if filled with powder to the muzzle. The Kalamazoo class of American Monitors is fitted with two screws, and the armour on the sides is 14 inches thick.

Subordinate Features of Monitor Vessels.—The presiding principle in the design of Monitor vessels is the principle of concentration. The armour is collected into a narrow belt of great thickness, and into a single turret, while the guns are collected into two pieces of great size. On the Dictator, the armour belt is 6 feet deep, of which only 16 inches appears above the water. This armour constitutes a belt 4 feet thick, applied to the outside of the ship, and consequently projecting several feet beyond the stem, this belt being prolonged at the stem and stern, to form a ram at each end, and also to protect the rudder and the screw from shot. The turret is placed in the centre of the ship: it is 24 feet in internal diameter, and 9½ feet high, and to the top of it a bell mouth 3½ feet high is attached to throw off any water that may dash against it. The top of the turret is covered with strong bars of iron, set about two inches apart, over which are spread perforated iron plates 1 inch thick. The turret is for the most part built up of thicknesses of inch plate riveted together, but the central part is formed of thick slabs of wrought iron, the collective thickness of the whole being 15 inches. The guns are two of Rodman's 15-inch guns, which can burn 60 lbs. of powder. The pilot house is a cylindrical iron chamber, 8 feet diameter, 7 feet high, and 13 inches thick, set on top of the central pillar or spindle, round which the turret revolves. The iron wall of the pilot house is pierced with sight holes. Within the pilot house, the steering wheel is placed, and the captain of the vessel can there direct the steersman, while the gunners are below the grated platform on which he stands, and therefore easily accessible to instructions. The ventilation of the ship is maintained by fans, which suck the air through high trunks or tubes, made shot-proof, and also inaccessible to rain or spray, the top being covered by a hood. The air, after having traversed the ship, finally enters the furnaces and escapes by the chimney, the bottom part of which is made shot-proof, and a grating of bars is also carried across it to prevent shells from being sent

through the chimney into the flues of the boiler. The bell mouth of the turret has a promenade or platform carried round its edge; and a narrow grated hurricane deck, supported on pillars, is carried from the after side of the turret for some distance towards the stern. From this deck the ship's boats are suspended.

Performance of Monitors as Cruisers at Sea.—Captain Fox, the assistant secretary of the American navy, reported as follows to his government on the performance of the Monitor vessel Miantonomah, on her voyage across the Atlantic, as illustrating the efficiency of such vessels as fighting cruisers. 'The facts with regard to the behaviour of this vessel in a moderate gale of wind and heavy sea, when a frigate would find it impossible to use her battery, are as follows: With head to the sea she takes over about 4 feet of solid water, which is broken as it sweeps along the deck, and after reaching the turret is too much spent to prevent the firing of the 15-inch guns directly ahead. With broadside to the sea, either when at rest or while moving, her lee guns can always be worked without difficulty—the water which passes along the deck from windward being divided by the turrets, and her extreme roll so moderate as not to press her lee guns near the water. Lying in the same position, her 15-inch guns can be fired directly astern without interference from water; and when stern to the sea, the water which comes on board is broken up in the same manner as when going head to it. . . . The extreme lurch, when lying broadside to the sea in a moderate gale, was 7° to windward and 4° to leeward, average 5½°, while the average roll at the same time of the Augusta, a remarkably steady ship, was 18°, and of the Ashuelot 25°, both vessels being steadied by sail. A vessel which attacks a Monitor in a seaway must approach very close to have any chance of hitting such a low hull, and even then the Monitor is half the time covered by 3 or 4 feet of water, protecting her and disturbing her opponent's fire. From these facts, not unknown to Monitor men, and the experience we derived from the use of such vessels during the war, we may safely conclude that the Monitor type of iron-clads is superior to the broadside, not only for fighting purposes at sea, but also for cruising. A properly constructed Monitor possessing all the requirements of a cruiser, ought to be constructed of iron and have but one turret, armed with not less than 20-inch guns, two independent propellers, and the usual proportion of sail.'

In regard to comfort and healthfulness, it appears, by a report presented by the secretary of the United States Navy to Congress, that the Monitors are the healthiest vessels in the American fleet, and they are also the most popular with the seamen. The cabins are lighted from the deck with bulls'-eyes, proper shutters being provided to cover these lights when the vessel goes into action, at which times the cabins are lighted by lamps alone.

On the subject generally, it may be added that the following opinions are entertained by some who advocate the adoption of Captain Coles' system. There is nothing in his design, it is urged, to preclude artificial ventilation; and it is affirmed that the narrow orifice between the upper deck and the turret is covered with a weighted massive leather flange, amply sufficient to keep out splinters; that under the heaviest fire at short range, under the most disadvantageous circumstances, the turret never has jammed, whereas those of the Monitors have done so; that they prefer hand-winches as motors, though there is nothing in the system to preclude a donkey engine for the purpose; that a worse pressure is exercised on the ship by a heavy turret on a spindle, than when diffused on its periphery; that the Monitor turret has to be lifted completely off its metal ring before it can be made to revolve, and that a trifling derangement would then upset the working of the spindle; and lastly, it is urged against the Monitors, that the whole height of the turret offers a perpendicular mark to the enemy, being entirely above the upper deck, while the Coles turret only exposes some four or five feet in which the guns are worked.

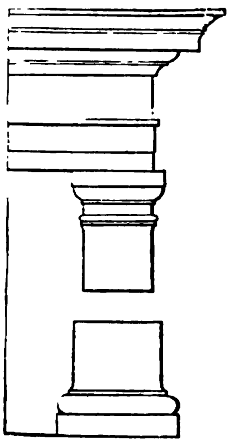
On the other hand, however, it is alleged, by those who think less favourably of Coles' system, that though there is nothing to hinder artificial ventilation in his more than in other vessels, yet that its adoption would only be a new appropriation of Ericsson's ideas, similar to that which took place when Coles discarded his own sloping shields in favour of the Monitor turret; that the weighted massive leather flange must present such enormous friction as to hinder rotation if sufficiently weighted to be splinter-proof; that if Monitor turrets have ever jammed (which is not admitted), the event has been exceptional, and that the Monitors, after having been each on the average twenty-five times in action during the course of the American civil war, remained practically unharmed at its close, whereas Coles' vessels have never been similarly tested; that the Monitor turrets may be rotated without lifting the spindle, though the lifting of the spindle is advisable, and that there is no risk of upsetting them when thus lifted, since they are lifted so little that the least springing of the spindle, such as would occur on the application of any side strain, causes the edge of the turret to rest on the deck ring; also, that Monitor turrets need be no higher than Coles' turrets, as both have only to keep the ports sufficiently clear of the deck to obviate injury to the deck from the cone of explosion.

Turrilepas (Lat. turris, *a tower*, and lepas; Gr. λεπάς, the word applied originally by Linnæus to the barnacles). A new genus of pedunculate Cirriped Crustacea, discovered by Mr. H. Woodward in the Wenlock Limestone of Dudley, and up to the present time the oldest known cirripede. It possesses intersecting rows of plates, symmetrically disposed like those of the chalk form of parasitic Cirriped *Loricula*.

Turtle (Lat. turtur). This word is used to signify a species of dove (*Columba turtur*), and also a genus of Chelonian reptiles (*Chelone*, Brongn.).

Tuscan Language. A name proposed in the sixteenth century to designate the language now known as the Italian, but which some desired to characterise as Florentine. (Hallam, *Literary History*, part i. ch. ix. sec. 31.) [ROMANCE LANGUAGES.]

Tuscan Order. In Architecture, one of the five orders, and the simplest of them all.



It is not found in any ancient example. Palladio has given two examples of this order, from one of which the profile here given is adopted, though some have preferred the profile composed by Vignola. The base consists of a simple torus with its fillet, accompanied by a plinth. Sir William Chambers assigns to the column, with its base and capital, a height equal to seven of its diameters. Vitruvius speaks of this order with little praise, but Palladio commends it for its great utility. It does not allow the introduction of ornament; and its columns are never fluted.

Tussac Grass. A name given to the *Dactylis cæspitosa* of the Falkland Isles.

Tutenag. An alloy of copper, zinc, and nickel, made in China; the term is also sometimes applied to a pale brass, and to bell-metal. [PAKFONG.]

Tutors. At Oxford and Cambridge, each college maintains a certain number of tutors, varying according to its size: at some, each undergraduate is placed under one of these tutors; at others, the work to be done is classified and divided between the tutors. They are, in general, fellows of the college, and are paid by fees. [UNIVERSITIES.]

Tutti (Ital.; Lat. totus, *the whole*). In Music, a notice to the performer that, from the place to which it is affixed, all the parts are to play together. This word is generally used to contradict the word SOLI or SOLO.

Tutty. An impure oxide of zinc collected from the chimneys of the smelting furnaces.

Twelfth Day. The festival of the Epiphany, or Manifestation of Christ to the Gentiles; being the twelfth day, exclusive, from Christmas. [EPIPHANY.] For the customs peculiar to this day in England, see Brand's *Popular Antiquities*.

Twelve Tables, Laws of the. In Roman History, the name given to the tables which were said to contain the legislation of the DECEMVIRI. This legislation is asserted to have been based on Greek models, but for this there is not the slightest historical evidence, while the story of the Tables is itself full of contradictions. According to Dionysius and Livy, the decemvirs in their first year of office framed a code inscribed on ten brazen tables (one for each decemvir), which received the sanction of the senate, and were fixed up in a conspicuous part of the forum. After this, according to Livy, the decemvirs who wished to resign were kept in office by the people, who thought that two tables were wanting to complete the code, and who, having come to hate the name of consuls scarcely less than that of kings, regarded the appeal from one decemvir to another as supplying the place of tribunitian interference. According to Dionysius, the decemvirs not only wished to retain irresponsible power in order to complete their code, but desired to prolong the suspension of the tribuneship. Of the character and contents of the two tables, said to have been added in their second year of office, Livy says nothing. According to Dionysius, they were added by Appius Claudius, and contained a prohibition of marriages between patricians and plebeians. Cicero mentions this prohibition as one of his reasons for drawing a broad distinction between the ten and the two later tables, which he stigmatises as unjust. But, according to Dionysius, and even according to Livy, the idea of the decemviral legislation was democratic, this character being involved (1) in the equalisation of the rights of plebeians and patricians, and (2) in the substitution of written laws for unwritten customs, a practice regarded by the Greeks as of democratic tendency.

The text of the twelve tables has been lost, as well as the description which Dionysius gave of their contents; but Sir G. C. Lewis maintains that, 'we know enough concerning them to authorise us in saying that they had not the character of a constitutional code, and that they contained nothing which placed the plebeians on a footing of political equality with the patricians. The political inequality between the two orders remained not less after the decemviral legislation, than it had been before. All the great constitutional changes, by which the plebeians achieved this equality, are mentioned as separate and successive measures, after the fall of the decemvirs. There is therefore nothing in the results of the decemviral legislation to explain the eagerness of the plebeian body to obtain it; the laws have not the character which we are told that they were intended to possess.' But our accounts assert that the ten tables were framed in accordance with the wishes of the plebeians, and as they appear to have contained nothing by which those wishes were carried into effect, 'the accounts of the purposes and circumstances of the legislation cannot be reconciled with its results,' and the conclusion is that 'the entire subject of the enactment of the decemviral code is in a state

of hopeless confusion.' (*Credibility of Early Roman History*, ch. xii. part iii. sec. 54.)

Twelve-hind Man. [THANE.]

Twelvemo. In Printing, the same as DUODECIMO.

Twenty-fours. In Printing, a sheet of paper which, when printed, folds into twenty-four leaves or forty-eight pages. The book is called a 24^{mo}.

Twilight (Ger. zwielicht). In Astronomy, the faint light which is perceived for some time after sunset and before sunrise.

The twilight is produced by the reflexion of light from the atmosphere. When the sun descends below the horizon, the rays of light no longer reach the earth directly; but as they pass through the atmospheric strata some of them are reflected towards the earth, and illuminate its surface. At first the light, falling on the lowest and densest strata, is reflected in great abundance; but as the sun descends to a greater distance below the horizon, the rays fall on strata at a greater height, and consequently less dense. A smaller number of them, therefore, suffer reflexion; and as this number is constantly diminishing, the strength of the twilight diminishes in the same proportion, till at length the solar rays fall on strata so rare as to be incapable of reflecting light, and the twilight accordingly disappears. In the morning the change from darkness to light takes place by the same gradations.

From this theory it is evident that twilight must begin and end when the sun's depression below the horizon attains a certain limit. The limit, however, cannot be fixed with any precision. It is usually estimated according to the time which elapses from sunset till the smallest stars which are seen by the naked eye become visible. But this mode of estimating the duration of twilight is uncertain and arbitrary; and it will be reckoned greater or less according to the goodness of sight of the observer, and the temperature and pressure of the atmosphere. Accordingly, the sun's depression at the beginning and end of twilight has been fixed at various limits by different observers: by Alhazen, at 19°; by Tycho, at 17°; by Rothman, at 24°; by Stevinus, at 18°; by Cassini, at 15°; and by others at different quantities; but the limit usually assigned is 18°.

Twilight of the Gods. [ODIN.]

Two-line Letters. In Printing, capitals which are equal to two bodies of any specific size of type. They begin with 2-line pearl (equal in depth to a longprimer), and increase regularly up to a 2-line great primer. They are used for lines in title-pages, the large letters at the beginning of advertisements in newspapers, &c.

Tycoon. The name by which the hereditary prime minister of Japan is commonly known to Europeans. This title, it seems, is applicable to the real emperor only, who is styled *mikado*, and who by Europeans is supposed to be only a spiritual sovereign, while the tycoon is the temporal ruler. The distinction is, apparently, erroneous, the relation of the so-called tycoon to the mikado being precisely that of the Frankish MAYORS OF THE PALACE to the Merovingian kings. Like the latter, the mikado is kept as much secluded as possible from the knowledge and observation of strangers and foreigners, while the tycoon, properly called *thoorgum*, wields the whole power of the state by holding in his possession the capital Yeddo, while for his authority he falls back on the emperor or mikado, for whom the reverence of the Japanese is so great that they will obey any usurper who holds his person and rules in his name.

Tylophora (Gr. τύλος, *a knot*, and φέρω, *to bear*). A considerable genus of *Asclepiadaceæ*, confined to the tropical and warm regions of the Old World; and consisting of twining mostly thin-leaved herbs or shrubs, bearing slender flower-stalks proceeding from between the leaves, and having umbels of small flowers disposed alternately along them. *T. asthmatica*, a twining shrubby species with slender branches, native of the Indian Peninsula, Ceylon, the Moluccas, &c., yields a strong white silky fibre resembling that of the Yercum (*Calotropis gigantea*). Its roots also possess valuable medicinal properties, acting in large doses as an emetic, in consequence of which they are substituted in India for ipecacuanha, and in smaller doses are used as a cathartic. They have been successfully employed in epidemic dysentery, and are said to have a good effect in humoral asthma. The Cingalese call the plant Binooga, and the natives of Madras, Koorinja.

Tympan. [PRINTING.]

Tympanitis or **Tympany** (Gr. τυμπανίτης). A distension of the abdomen, arising from a morbid collection of gas in the intestines. The disease is sometimes termed *drum belly*, and arises occasionally from air secreted into the abdominal cavity, at the fatal termination of abdominal inflammations and of fevers. In cattle, this disease is known to veterinary practitioners under the name of HOVEN.

Tympanum (Lat.; Gr. τύμπανον, *a drum*). The drum of the ear; the cavity behind the membrane of the tympanum, surrounded by the tympanic, mastoid, and petrous portion of the temporal bones, and terminating at the labyrinth; it contains the four small auditory bones, and the Eustachian tube opens into it.

TYMPANUM. In Architecture, the space in a pediment enclosed by the cornice of the inclined sides and the horizontal fillet of the corona.

TYMPANUM. In Botany, a membrane which stretches across the mouth of the spore-case of some urn-mosses.

Type (Gr. τύπος, literally, *a blow*, hence the mark left by a blow). In the Fine Arts, the model or pattern, in nature, of any object. Thus, in architecture, the types of columns are said to be trees, &c.

TYPE. In Printing, the letters, marks, and signs of all kinds (the small sizes cast in metal, the largest cut in wood) with which books, newspapers, broadsides, &c. are printed.

Roman and Italic types are the letters most commonly used in printing books in Europe and America, and these have undergone every change in form that fancy or taste could suggest: *fat-faced*, or those which print black; *skeleton*, or those with a fine uniform line; *antique*, or those with an almost uniform thickness, but strong and heavy; *clarendon*, a modification of antique; *expanded*, or letters widened horizontally; *Elzevir* and *compressed*, or tall, thin letters; *Baskerville*, a good, round, bold face; *Italic*, inclining to the left as well as to the right; *black*, and all its varieties of *church-text*, *German text*, *Gothic*, and *Elizabethan*; *old cut* and *old style*; *script*, &c.

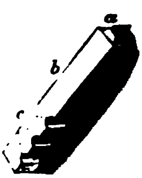
The scale of sizes given below from Savage shows the variations in the depth of the types cast by the different founders.

Number of Lines of the different sized Types contained in One Foot.

	Moxon, 1683	Caslon, 1841	V. and J. Figgins, 1841	Thorowgood and Besley, 1841	Alexander Wilson and Sons, 1841
Diamond	—	204	205	210	204
Pearl	184	178	180	184	178
Ruby	—	166	165	163	166
Nonpareil	150	144	144	144	144
Emerald	—	—	128	—	128
Minion	—	122	122	122	122
Brevier	112	111	107	112	111
Bourgeois	—	102	101½	103	102
Longprimer	92	89	90	92	89
Smallpica	—	83	82	82	83
Pica	75	72	72½	72	72
English	66	64	64	64½	64
Greatprimer	50	51	51	52	51
Paragon	—	44½	44½	—	44½
Double pica	38	41½	41½	41	41½
Two-line pica	—	36	36	36	36
Two-line English	32	32	32	32¼	32
Two-line greatprimer	—	25½	25½	26	25½
Two-line double pica	—	20¾	20¾	20½	20¾
Trafalgar	—	20	20	—	20
Canon	17½	18	18	18	18

It will be seen that in Moxon's time, in 1683, there were only ten types with specific names, while we have now twenty-one.

The type itself is a thin metallic bar, an inch in length, like the following engraving, which represents the letter *m*; *a* is the *face*, *b* the *body*, and *c* the *nicks* or notches. Whatever size of type is used, each letter must be perfectly true in its angles, otherwise the form, or mass of types, could never be *locked up*.



The materials from which types and stereotype plates are cast are technically termed *metal*, and consist of certain proportions of lead, tin, and antimony, melted together. Until recently types were always cast in little moulds held in the hand, the melted metal being poured in from a small ladle; but now they are thrown off with great rapidity by machinery. The type-casting machine consists of a mould, constructed so as, by means of a crank, to open for the purpose of letting the type drop out, and then to shut up together again very closely and exactly; the opening and shutting being performed every time the crank is turned once round. Each time the crank revolves, it is brought up to the furnace-mouth (a small orifice not much larger than a pin-hole), and takes a supply of metal. This metal is driven by a force-pump in a reservoir, worked by the crank, into the mould, and the type is formed. The types are then rubbed smooth upon stones; *set up*, or arranged in rows, for inspection by the *dresser*, who carefully examines them, and rejects those which are bad, giving the perfect ones the finishing touch. The most complete process is, perhaps, that of Messrs. Johnson and Atkinson. A double line of grooves is placed side by side. At one end is a reservoir of molten metal, to which the mould is brought; a jet of metal is thrown into the mould, which then opens, and deposits the type on a travelling apparatus in the groove. As the groove fills, it is impelled along, and in its progress the shanks are taken off. At the end the position of the type is reversed by the machinery into the returning groove, in which it is rubbed, dressed, has the bottoms planed, and the nicks cut. On arriving at the exit end of the groove it is received into a type-founder's stick, which has to be removed as it is filled, and the type is then ready for packing. The great advantage of type machines consists in the increased facility of production. One machine and one man will produce in ten hours 30,000 brevier types (or 60 lbs.), while

by hand labour only 5,000 (or 10 lbs.) could be cast in the same time. Messrs. Miller and Richards, of Edinburgh and London, employ not less than eighty steam type-casting machines, equalling in production the labour of 480 men.

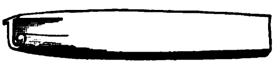
The beauty of type depends upon the delicacy with which the *matrix*, or mother type, is formed. This mould is a short thick bar of copper, with the form of the letter intended to be produced stamped in one side of it, thus:—

The letter in the matrix is stamped in by means of a punch, a small piece of steel,

Bill of Pica.—Weight 800 *Pounds.—Italic* $\frac{1}{10}$.

a	8,500	è	100	0	1,300	K	150
b	1,600	ì	100	£	—	L	250
c	3,000	ò	100	A	600	M	200
d	4,400	ù	100	B	400	N	200
e	12,000	â	200	C	500	O	200
f	2,500	ê	200	D	500	P	200
g	1,700	î	100	E	600	Q	90
h	6,400	ô	100	F	400	R	200
i	8,000	û	100	G	400	S	250
j	400	ä	100	H	400	T	326
k	800	ë	100	I	800	U	150
l	4,000	ï	100	J	300	V	150
m	3,000	ö	100	K	300	W	200
n	8,000	ü	100	L	500	X	90
o	8,000	ç	100	M	400	Y	150
p	1,700	,	4,500	N	400	Z	40
q	300	;	800	O	400	Æ	20
r	6,200	:	600	P	400	Œ	15
s	8,000	.	2,000	Q	180		
t	9,000	-	1,000	R	400	*Spaces.*	
u	3,400	?	200	S	500	Thick	18,000
v	1,200	!	150	T	650	Middle	12,000
w	2,000	'	700	U	300	Thin	8,000
x	400	†	100	V	300	Hair	3,000
y	2,000	‡	100	W	400	m qd.	2,500
z	200	*	100	X	180	n qd.	5,000
&	200	[	150	Y	300		
fi	500	‖	100	Z	80	Large	
ff	400	§	100	Æ	40	quad:	
fl	200	(	300	Œ	30	2 em.	
ffl	100	¶	60	A	300	3 em.	{ about
ffi	150	1	1,300	B	200	4 em.	80 lb.
æ	100	2	1,200	C	250		
œ	60	3	1,100	D	250	Metal	
á	100	4	1,000	E	300	rules:	
é	250	5	1,000	F	200	1 em	—
í	100	6	1,000	G	200	2 em	—
ó	100	7	1,000	H	200	3 em	—
ú	100	8	1,000	I	400		
à	200	9	1,000	J	150		

a letter cut upon one end, and the other end a flat head to receive the blow of a hammer.



The length of the body of a type is called its *height to paper*, and this is unfortunately not uniform, there being a *London* and a *Scotch* height, the former not so high as the latter.

A complete assortment of types is called a *fount*, which may be regulated to any extent. Every type-founder has a scale showing the proportional quantity of each letter required for a fount; and a peculiar scale is required for each language. For the English language, a type-founder's scale, or *bill*, for a fount of the weight of 800 lbs. is given above, from which it will be seen that in the English language the letter *e* is more frequently used than other letters, and *z* the least. In setting up indexes and similar matter, the capitals mentioned in the scale would be considerably deficient. This would also be the case with French and Italian works, where accented letters are used in great numbers.

In the last century, a fount of type weighing 500 lbs. was considered a good weight; but now,

so much has printing increased, it is not an uncommon thing in the principal houses in London to keep a fount of 20,000 or 30,000 lbs. in constant use. The following are the names of the types in English, Dutch, French, German, and Italian; but some of the German names vary in different parts of Germany.

1. Diamond, the smallest.
2. Pearl. (*Fr.* La Parisienne or Sédanoise; *Ger.* Perl; *Ital.* Occhio di Mosca.)
3. Ruby.
4. Nonpareil. (*Dutch*, Nonpareil; *Fr.* La Nonpareille; *Ger.* Nonpareille; *Ital.* Nompariglia.)
5. Emerald.
6. Minion. (*Fr.* La Mignonne; *Ger.* Colonell; *Ital.* Mignona.)
7. Brevier. (*Dutch*, Brevier; *Fr.* Le Petit Texte; *Ger.* Petit, or Jungfer; *Ital.* Piccolo Testo.)
8. Bourgeois. (*Dutch*, Bourgeois; *Fr.* La Gaillarde; *Ger.* Burgeois; *Ital.* Gagliarda.)
9. Long Primer. (*Dutch*, Garmond; *Fr.* Le Petit Romain; *Ger.* Corpus, or Garmond; *Ital.* Garamone.)
10. Small Pica. (*Dutch*, Dessendiaan; *Fr.* La Philosophie; *Ger.* Brevier, or Rheinländer; *Ital.* Filosofia.)
11. Pica. (*Dutch*, Mediaan; *Fr.* Le Cicéro; *Ger.* Cicero; *Ital.* Lettura.)
12. English. (*Dutch*, Augustyn; *Fr.* Le Saint Augustin; *Ger.* Mittel; *Ital.* Silvio.)
13. Great Primer. (*Dutch*, Text; *Fr.* Le Gros Romain; *Ger.* Tertia; *Ital.* Testo.)
14. Paragon. (*Dutch*, Paragon; *Fr.* Le Petit Parangon; *Ger.* Paragon; *Ital.* Paragone.)
15. Double Pica. (*Dutch*, Dubbelde Dessendiaan; *Fr.* Le Gros Parangon; *Ger.* Text, or Secunda; *Ital.* Due Linee Filosofia.)
16. Two Line Pica. (*Dutch*, Dubbelde Mediaan; *Fr.* Les Deux Points de Cicéro; *Ger.* Doppelcicero.)
17. Two Line English. (*Dutch*, Dubbelde Augustyn; *Fr.* Palestine; *Ger.* Doppelmittel; *Ital.* Canoncino.)
18. Two Line Great Primer. (*Dutch*, Kanon; *Fr.* Petit Canon; *Ger.* Kleine Canon; *Ital.* Grosso Testo.)
19. Two Line Double Pica. (*Dutch*, Groote Kanon; *Fr.* Trismegiste; *Ger.* Grobe Canon.)
20. Trafalgar.
21. Canon. (*Dutch*, Parys Romeyn; *Fr.* Le Gros Canon; *Ger.* Kleine Missal; *Ital.* Canone.)

Canon is the largest English size with a specific name; Pica then becomes the standard to distinguish them, and the next size to Canon is Four Line Pica, then Five Line Pica, and so on, to the largest size used in posting bills.

Subjoined is a specimen of the sizes of types up to Great Primer inclusive, the numbers corresponding to the numbers and names above.

1. To enable the reader to form an opinion of the comparative sizes of
2. types, and the proportions they bear to each other, there is given
3. in this paragraph a line of each size, from Diamond, the
4. smallest type in general use in England, up to Great
5. Primer, inclusive, numbered to correspond with
6. the preceding list, in order to distinguish
7. them by their names. There is a smaller
8. type than Diamond lately introduced,
9. but it is as yet little used. The
10. French have one so small that
11. it cannot be read by the
12. naked eye, even by
13. young persons.

In 1457 cast types were invented by Peter Schoeffer; in 1800, the lever, or American mould, was introduced; in 1823, Henri Didot's polymatype, still successfully used in France, was worked in London by Pouchée, but failed through the opposition of the associated type-founders; in 1853, Mr. Johnson patented his machine for casting type mechanically without variation of body; and in the year following, he perfected his process for making hard metal type by substituting tin for lead entirely or partially in the ordinary compounds.

TYPE. Properly, the figure stamped upon a coin: hence, a sign or symbol, especially those by which it is said that Christ was prefigured to the Jews, whether figures, as the Brazen Serpent, the Lamb of the Passover, the Sacrifice of Isaac; or persons, as Moses, David, Jonah, &c.

Type of Constans. [ECTHESIS; HENOTICON.]

Type Metal. The alloy of lead and antimony used in casting printer's types, the usual proportions being one part of antimony to three of lead, but a superior and harder kind of type is sometimes made by alloying two parts of lead with one of antimony and one of tin. Both these alloys take a sharp impression from the mould or matrix, owing to their expansion on solidification, and they are hard enough to stand the work of the press, without being brittle or liable to fracture.

Typhaceæ. An order of Endogens, consisting of reed-like herbs growing in marshes, ditches, or shallow water, and having long narrow parallel-veined leaves, and small flowers densely packed in cylindrical spikes or globular heads. In structure they come near to *Araceæ*. The flowers are monœcious, without any perianth, unless the small scales or tufts of hairs intermixed with the stamens and ovaries be regarded as such. The ovary tapers into a slender simple style, and ripens into a small nut with a single pendulous seed; the embryo is straight, lying in copious albumen. There are very few species, but some of them are dispersed over nearly all parts of the globe. The genus *Typha* is a good illustration.

These Typhas are tall herbaceous aquatics, distinguished by their flowers forming a continuous spike or spadix shaped like a constable's mace. The two British species, *T. latifolia* and *T. angustifolia*, often popularly but erroneously called Bulrush (which name properly belongs to the genus *Scirpus*), are common on the borders of ponds and lakes, where their singular large terminal spikes (called from their form Cat's-tail, or Reed-mace) present so picturesque an appearance, that they are often selected by artists to indicate the presence of water. *T. latifolia* grows to the height of five or six feet.

Typhaon (Gr.). In Greek Mythology, this name is the same as that of Typhöeus, or Typhon; but in the Hesiodic *Theogony*, Typhaon and Typhöeus are distinct personages, the former being a son of Typhaon. In one tradition, the latter is described as a son of Gaia and Tartarus;

in another as a son of Hera, who produced him by her own unaided power, as Athena sprang armed from the forehead of Zeus. [TRITOGENEIA.] In another version it is Hephæstus, and not Typhaon, who stands in this relation to Hera.

Typhōeus is mentioned in the *Iliad* (ii. 782) as imprisoned in the country of the Arimi. By later poets he is connected with the Egyptian mythology, which, according to Sir G. Wilkinson, had two deities, 'one who was the brother of Netpe, and opposed to his brother Osiris, as the bad to the good principle; the other, bearing the name of Typho, and answering to that part of his character which represents him as the opponent of Horus.' (*Ancient Egyptians*, vol. iv. p. 417 &c.)

Typhon belongs to the same class of beings with ECHIDNA, FAFNIR, PYTHON, the SPHINX, &c.

Typhoon. The name given to a violent tornado or hurricane in the Chinese seas. [STORMS.]

Typhus (Gr. τῦφος, from τύφω, *to smoke*). This term (implying to burn with a concealed and smothered flame) is applied to certain continued fevers, attended by great debility. It is contagious or infectious, and often epidemic, and is most prone to attack debilitated persons, especially where aided by want of cleanliness, good food, and fresh air; so that it often spreads in hospitals, gaols, camps, and other situations where such causes assist its progress. This form of fever is liable to several modifications, commonly termed *low fever*, *putrid fever*, *nervous fever*, *gaol fever*, &c. Its attack is generally characterised by inordinate muscular and nervous debility, and by great depression of spirits, weariness, flying pains, sighing, and a frequent, small, and sometimes fluttering pulse; the tongue is foul and brown, and the taste impaired, and not unfrequently nausea and bilious vomiting prevail, constituting that variety of typhus which has been called *bilious fever*. About the fourth or fifth day, an eruption appears upon the abdomen, having a deep colour, approaching sometimes to extreme lividity. These spots do not disappear on pressure, like those of typhoid fever. As the disease advances, the debility increases; the mouth becomes very foul, and the breath fetid; the urine deposits a brown sediment, and, together with the motions, is fetid, and rapidly putrefies. All these symptoms increase in intensity; the speech becomes inarticulate, muttering, and delirious; there is a tendency to bleeding from the nose, mouth, and bowels; petechiæ, or livid spots, appear upon the surface; the pulse sinks and intermits; the mind wanders; hiccup comes on; the hands and feet become cold; and, under these horrible symptoms, the patient dies. Such is an outline of the progress of a typhus fever to a fatal termination. In this climate it may endure for from two to three weeks; but in hot countries the symptoms follow each other more rapidly and violently, and it is not of more than eight or ten days' duration. When it does not terminate fatally, the symptoms begin to assume a more favourable aspect about the fourteenth day; the pulse improves, the patient gets some tranquil sleep, perhaps perspires; the urine deposits a red sediment; bilious stools are passed; he becomes more tranquil in mind and body, and his symptoms gradually disappear till health is restored; but it is a disease the event of which must be anticipated with the utmost caution, for attacks apparently mild sometimes terminate fatally, and in other cases the constitution has rallied under the most alarming and malignant features. At the very commencement an emetic sometimes acts advantageously. It is possible that some particular symptom, indicative of local congestion, may call for treatment. Serpentaria, Peruvian bark, cascarilla, and colombo are the tonics which have been most relied on, but in the present day little else is used than mild nourishing fluid diet, and alcoholic stimulus as the case progresses, or sometimes at the onset. In all cases, the utmost attention must be paid to extreme cleanliness, frequent change of linen, ventilation, and the due use of disinfectants.

Typography. The art of Printing. [PRINTING.]

Tyr. In Teutonic Mythology, the sun-god, answering to the Vedic Dyu. Like SAVITAR, he is represented as one-handed; but the German story is that Tyr placed his hand as a pledge in the mouth of the wolf, and that the wolf bit it off. With the two legends which relate the mutilation of Tyr and Savitar may be compared the Norse and African tales, which profess to account for the tailless condition of the bear and the hyæna. (Dasent, *Popular Tales from the Norse*, li.)

In the Edda, Odin is the supreme god, but there is evidence that before his pre-eminence was established, Tyr was worshipped as the principal deity of the Germans, being etymologically the same as the Greek ZEUS. The name survives in the Anglo-Saxon Tiwesdæg, *Tuesday*; in the names of places, as Tewesley, Tewing; and of flowers, as in the old Norse Týsfiola, Týsvidr. According to Tacitus, the Germans spoke of themselves as sprung from Tuisco (Zeus), and his son Mannus. [MINOS.] This Mannus is the Sanscrit Manu, from the root *man*, to measure, to think, from which is derived the Old High German *mennisc*, and the modern *mensch*, *mennisc* meaning a son of man. 'As soon as *mennisc* and *manushya* became in common parlance the recognised words for man, language itself supplied the myth that Manus was the ancestor of the Manushyas. . . . Hence *Mannu* was called the son of Tuisco, and this Tuisco, as we know, was originally the Aryan god of light.' Tacitus mentions the three tribes, Ingævones, Iscævones, and Herminones, as sprung from the three sons of Mannus. Of these, the first derive their name from Yng, Yngo, or Ynguio, whom the Edda has mentioned as living first with the eastern Danes, probably as Augê is to be found in Mysia, and Phœbus in the Lykian (Lycian) land. The second son, Isco, has been identified by Grimm with *Askr*, whose name means *ash-tree*, and thus embodies

probably the same conception which led the Greeks to speak of men as sprung (ἐκ μελιᾶν) from ash-trees. 'Alcuin still uses the expression *son of the ash-tree* as synonymous with man. The third son of Mannus, Irmino, has a name decidedly German. Irmin was an old Saxon god, from whom probably both Arminius and the Herminones derived their name.' (Max Müller, *Lectures on Language*, second series, x.)

Tyrannicide. [LIBERTY; REGICIDE.]

Tyrant (Gr. τύραννος). In the original sense of the word, a citizen who acquired sovereignty by subverting the constitution of a free state, whether by violence or stratagem, was called, in the language of Greek political writers, a tyrant, as distinguished from the *basileus*, or rightful hereditary king, whether despotic or constitutional. [LIBERTY; REGICIDE.]

Tyrite. A hydrous mineral allied to Fergusonite, occurring abundantly (sometimes in crystals more than two inches long) in a large felspar quarry at Helle near Arendal in Norway. It chiefly consists of columbic acid, yttria, alumina, the protoxides of cerium, uranium, lanthanium, and iron, lime, zirconia, and glucina.

Tyrolite. A hydrated arseniate of copper with carbonate of lime, composed of 25·4 per cent. of arsenic acid, 43·8 oxide of copper, 19·8 water, 11·0 carbonate of lime. It occurs at Falkenstein and other parts of the Tyrol (whence the name), usually in small reniform aggregations and diverging fibrous groups of a pale green colour, and with a pearly lustre. It is very sectile, and in thin laminæ flexible. [KUPAPHRITE.]

Tyrosin (Gr. τυρός, *cheese*). A crystalline substance originally obtained from cochineal. It is artificially produced by the fusion of caseine, fibrine, or albumen with potassa, or by boiling the same substances with dilute acids, and is sometimes the result of their putrefaction. The formula assigned to it is $C_{18}H_{11}NO_6$.

Tythe. [TYTHING.]

Tything. A tything was a subdivision, i.e. a tenth part, as its name indicates, of the hundred, with which it was probably coeval in institution, as it was certainly identical in object, so far at least as regards the prevention of offences by the condition of liability for the production of offenders, or in default thereof reparation of the mischief, in the case of offences committed within the district. For this purpose, all free persons above the age of twelve years were required by the Saxon law to belong to some tything. No jurisdiction appears to have belonged to the tything; and the office of tythingman, or constable, seems always to have been confined, as it is now, to the preservation of the peace, and the apprehension of offenders. The limits of a tything were in most cases coextensive with those of a parish, with which it is now commonly, for practical purposes, identical.

U

U. This letter was long identified with V, and both were used indiscriminately; but at the beginning of the sixteenth century their peculiarities came to be marked, and *u* has since been used as a vowel and *v* as a consonant.

Ubiquists or **Ubiquitarians** (Lat. ubique, *everywhere*). In Ecclesiastical History, a school of Lutheran divines: so called from their tenet that the body of Christ was present in the Eucharist in virtue of His divine omnipresence. Luther is said to have maintained this position, as a mode of reconciling the doctrine of transubstantiation with reason, for two years. Brentius, one of his disciples, passes for its principal supporter. Melanchthon opposed it; but it seems to have obtained great credit among the Lutherans of the sixteenth and seventeenth centuries.

Uckewallists. In Ecclesiastical History, a sect of rigid Anabaptists; so called from one Uke Wallis, a native of Friesland. They appear to subsist still, independent of other Anabaptists and Mennonites, in Friesland and Gröningen. (Mosheim, vol. v.)

Udal or **Udaller** (Dan. odel). A synonym of the Gothic and Frankish *alod*, a proprietor holding his lands under no feudal superior.

The settlers in France under Clovis parcelled out such lands as they appropriated into portions called alods, each allottee holding his own plot without any obligation to a feudal law, and being liable only to the general duty of defence—a duty which was known in later legal history by the name of TRINODA NECESSITAS. But the ancient population, now become Romanised, appear to have held the possessions relinquished to them by their conquerors on a lower and more precarious tenure. In course of time, however, the kings, whose powers increased with the settlement of the country, granted their followers and dependants, under the condition of attendance and military services, life estates, called *benefices*, or in the Frankish tongue *feuds*. Gradually and by insensible steps, as the allodialists became impoverished and insulated, they were forced to *commend* themselves to some lord, and the feudal system of homage, allegiance, and service, became general. This change was made more rapidly, as society was rendered more insecure by the danger of external aggression.

Among the Scandinavian races, the feudal system, in the absence of these contingencies, never took deep root, and consequently the old tenure survived, under the name *udal*, the owner

of the land being a *udaller*. This kind of occupation, which still characterises Norway, prevailed formerly in the Isle of Man, and is still found in the Orkneys and Shetland islands. The latter term, in something like the sense of an esquire or gentleman of estate, will be familiar to the readers of Scott's *Pirate*. On failure of heirs, such lands reverted in common to all owners on a similar title. Among Celtic races the custom of TANISTRY and GAVELKIND prevailed. It was probably in consequence of the reversionary interest of the sept or clan, that udal lands, even when sold, could always be redeemed within a fixed period by the seller. The following are illustrations of the tenure.

Prof. Keyser (*Norsk Church History*) says: 'The feudal system in its South German shape was unknown in Norway. In its stead the udal system prevailed, by which the land was the free possession of the udaller, over which the state or king had no superior right, and which it therefore could not tax. On the other hand, every Norwegian was bound to support the state by his *personal* service. In Norway, all services to the state were of a personal character, and did not depend on land or other property.'

See also the *Saga* of Olaf Tryggvason, 16. (*Flateybok*.) 'Hacon Athelstan was in England when he heard of the death of his father Harald the Fairhaired.' He started at once for Trondhjem, and at the Thing 'stood up and spoke as follows. He commenced by asking the bonders (peasants) to call him king and help him to hold the kingdom; in return for which he offered to make all the bonders odalbornna (udalborn), and give them their udal possessions (odul sin) on which they dwelt.'

'Again in the same saga (183), when Harald imposed a tribute on the Orkneys, earl Einar offered to pay the whole of it himself, if the peasants would give up their udal rights.'

Uigite. A hydrated silicate of alumina, lime, and soda, found in the amygdaloid of Uig in Skye.

Ukase. An ordinance of the emperor of Russia having the force of law in his dominions.

Ulcer (Lat. ulcus, Gr. ἕλκος, *a wound*). A solution of continuity in any of the soft parts of the body, attended by a purulent or other discharge. The several kinds of ulcers are divided by surgeons into *local* and *constitutional*, but these often run into each other. They have been termed *simple* and *specific* sores or ulcers: the former resulting from accidental injuries, the latter from specific poisons or particular habits of body. (Cooper's *Surgical Dictionary*.)

Ule-tree. The name of a tree from which caoutchouc is obtained. It is supposed to be the *Castilloa elastica*.

Ulema (Turk. *learned men*). The college or corporation composed of the three classes of the Turkish hierarchy: the *imans*, or ministers of religion; the *muftis*, or doctors of law; the *cadis*, or administrators of justice. This organisation, according to D'Ohsson (*Tableau de l'Empire Ottoman*), was first framed by the caliphs, and adopted, along with the other principles of their government, by the Ottoman sultans. Candidates for admission in the Ulema are educated at the different colleges (medressés) of the empire. The *Sheikh ul Islam*, or mufti of Constantinople, is the president of the whole body. (*Ed. Rev.* vol. l.)

Ulex (Lat.). A genus of prickly shrubs of the order *Leguminosæ*, distinguished by their twoparted calyx bearing two minute bracts at the base, and their turgid few-seeded legume. *U. europæus*, the Common Furze, Whin, or Gorse, is one of the few British social plants sufficiently important to give a name to the localities on which it fixes, a *Furze-brake* being a characteristic feature of English landscape. Harsh and rugged though Furze be in appearance, it has by no means a wide geographical range. Even in North Britain it dwindles in size, and in the more exposed regions is hardly known. In Russia and Sweden it occurs only as a greenhouse plant, and even in the south of England an unseasonably severe frost nips the flowers, or sometimes destroys all the exposed part of the plant. When regularly cut down every year, the annual shoots of the Furze, mowed as wanted, and bruised to deaden the prickles, supply a green food throughout the winter, which all animals, and especially horses, are particularly fond of. When cultivated, the seeds sown are either collected from the wild plants, or from a variety which, by successive cultivation, has become rather more succulent and productive. The double-flowered Furze of gardens is a variety of this species, as is also the Irish Furze, distinguished by the softness of its upright branches. *U. nana*, the Dwarf or French Furze, a much smaller plant, with flowers of a deeper yellow, blooms in the greatest profusion at the season when heath is in blossom, with which it harmonises beautifully in colouring.

Ulexite. A name given to native borate of lime (Hayesine), after Ulex, by whom it was analysed.

Ullage. In Gauging, this word is used to denote that quantity which a cask wants of being full.

Ullmannite. A sulphide of nickel and antimony; the latter often partly replaced by arsenic. It generally occurs massive, with a granular structure; or disseminated, and is of a grey colour inclining to tin-white or steel-grey; opaque with a metallic lustre. It is chiefly found in the copper mines of Frensberg, Eisern, &c. in the duchy of Nassau; in Siegen, Prussia; and at Harzgerode and Lobenstein in Central Germany. Named after Ullman, by whom it was analysed.

Ullucus. [MELLOCA.]

Ulmaceæ (Ulmus, the principal genus). A natural order of woody plants, usually timbertrees, inhabiting temperate climates. They are apetalous Exogens, nearly allied to the Urticaceous order, from which they principally

differ in having a two-celled fruit. The various kinds of Elm-trees are the best known species; but the thin papery fruit of these plants is merely a character of the genus *Ulmus*, and by no means characteristic of the order.

Ulmin (Lat. ulmus, *the elm-tree*). A dark brown substance which exudes from the bark of the elm and several other trees, and which appears to be contained in most barks. The brown matter found in decayed leaves and wood, and in soils abounding in decomposed organic substances, resembles ulmin. [HUMIC ACID.]

Ulmus (Lat. *an elm*). A genus of *Ulmaceæ*, consisting of hardy deciduous trees, some of which yield the valuable timber called *Elm wood*.

The Common Elm, *U. campestris*, is the most generally diffused species, though said to have been introduced into Britain by the Crusaders. It is a lofty upright-growing tree, composed of many tiers of spreading branches, which often hang in graceful festoons at the extremities. The Wych Elm, *U. montana*, is distinguished by its numerous spreading branches, which frequently droop so as to conceal the main trunk. The Elm was held in high estimation by the ancients, partly for the sake of its leaves, which were dried and employed as fodder, and partly for the use to which the tree itself was applied, viz. as a prop for vines. The former custom still obtains in some parts of the Continent; but the Elm is now principally valued for its timber, which is fine-grained, tough, possessing great lateral adhesion, and remarkable for its durability under water. Hence it is employed in naval architecture. It was formerly much used in making water-pipes. The Elm, growing in good soil, arrives at perfection in 150 years, but will live for 500 or 600 years. The Common and Cornish Elms are considered to afford the best timber.

The *Ulmus montana* is often called the Wych Elm and Witch Hazel, probably from the similarity of its leaves to those of the hazel-nut; and hence, like it, its twigs were formerly employed for riding-switches to insure good luck on the journey. Forked branches of Wych Elm, as of hazel, were used as divining rods. They were more usefully employed for making long bows, the archer esteeming them next to those of the yew for that purpose.

Ulna (Lat.; Gr. ὠλένη). The larger of the two bones of the forearm. It forms the joint of the elbow, and is articulated by a species of hinge-joint to the humerus, and to the radius; and below to the radius and to the bones of the wrist.

Ulnage or **Ulnager** (Lat. ulna, *an ell*). Edward I. and his grandson sought to naturalise the industry of the Flemish weavers in England, and settled a considerable number of these artificers in the eastern counties, which, in the fourteenth century, became the richest and most prosperous parts of England. But they did not prohibit the importation of foreign cloth, though they watched with considerable jealousy the exportation of British wool.

Partly, however, in order to prevent frauds on the customs, much more in order to secure the buyer of foreign stuffs, officials were appointed in each considerable port, who should measure and certify the length and quality of the piece (pannus) of 24 yards or ells; for in early times it seems that these words were synonymous. These officers were called *alnagers* or *ulnagers*, and the accounts rendered by them to the exchequer are still preserved in great fulness and continuity in the Public Record Office.

It should be remembered that the police of the middle ages, imperfect as it might have been, was employed in the general interests of society, and consequently that the supervision exercised over dealers was continual and rigorous. In short, the maxim of law, *caveat emptor*, was interpreted in bygone times in a somewhat different form from that which modern usage assigns to it. In our own day, it is hardly possible for the general public, in the exercise of individual discretion, to guard against the ingenuity of fraudulent traders; but in those times, the police was incessant and effective, and the buyer who was defrauded, was as little an object of compassion, as the man would be who thinks proper to traffic with a real or pretended smuggler, and finds himself cheated.

Ultimate Analysis. This term is applied in Chemistry to the resolution of substances into their absolute elements, and is opposed to *proximate analysis*, by which they are merely resolved into secondary compounds. The ultimate analysis of crystallised blue vitriol, for instance, teaches us that its true elements are sulphur, copper, oxygen, and hydrogen; its proximate elements are sulphuric acid, oxide of copper, and water; the ultimate elements of sulphuric acid are sulphur and oxygen; of oxide of copper, copper and oxygen; and of water, hydrogen and oxygen. The terms *ultimate analysis* and *ultimate elements* are, however, most generally used in reference to organic products. Gum resin, starch, and sugar, are often found associated in a vegetable, and are called *proximate* principles, and they are separated by proximate analysis; but all these are resolvable by ultimate analysis into carbon, hydrogen, and oxygen. These three elementary substances, therefore, are their *ultimate* components. The accurate determination of the relative proportions of the proximate constituents of the various organic products is often a difficult chemical problem.

So, again, various animal products, such as albumen, fibrin, gelatin, casein, &c., which are separable as distinct proximate substances, are found, in reference to ultimate composition, to consist of carbon, hydrogen, oxygen, and nitrogen, to which sulphur and phosphorus, together with some mineral substances, are superadded. [ANALYSIS, in Chemistry.]

Ultimate Ratio. The ratio of evanescent quantities. [PRIME AND ULTIMATE RATIO.]

Ultimatum (Lat. ultimus, *last*). In Diplomacy, the final conditions offered by a government for the settlement of its dispute with another.

Ultra (Lat. *beyond*). In Modern Politics, those who carry to their farthest point the opinions of the party to which they belong are so termed. The name was applied in 1793 to the more violent revolutionists; it has since been bestowed on the extreme section of all parties in turn.

Ultra-elliptic Functions. [ELLIPTIC FUNCTIONS.]

Ultramarine (Lat. ultra, and mare, *the sea*). The blue pigment obtained from the mineral *lazulite* or *lapis lazuli*. The mineral is ground to a fine powder and levigated. *Artificial ultramarine* is prepared by heating to redness a mixture of kaolin, sulphur, and carbonate of soda. Other processes have been employed, but this yields the best results of those that have been published, although there is little doubt that the manufacturers make use of improvements upon published methods. The nature of the blue colouring matter of ultramarine has given rise to much discussion: some have thought that it is due to a peculiar kind of sulphide of sodium; but it has been found that the presence of iron is indispensable for the formation of the colour. That sulphur is one of the necessary constituents, is proved by the fact that the colour is destroyed by the action of acids, sulphuretted hydrogen being simultaneously liberated. A peculiar transient blue colour is produced on mixing sulphuretted hydrogen with perchloride of iron; this seems to indicate that both iron and sulphur are involved in the formation of ultramarine. The tint of the artificial product is superior to that of the natural, whilst the cost of its manufacture is so low as to render it one of the cheapest pigments known.

Ultramontane (Lat. ultra, and mons, montis, *a mountain*). In Ecclesiastical language, those who maintain the most advanced theory of papal supremacy are so called, as distinguished from those who hold that the authority of a general council is paramount to that of the pope. The name is derived from the circumstance that the theologians of Italy, the country beyond the Alps, were considered more favourable to high papal doctrine than the Cismontane doctors of France and Germany. Although among the modern clergy of France the respective names of Frayssinous, Affre, Boyer, and Guillon have been added to the catalogue of the defenders of Gallican liberties, yet the *ultramontane* spirit is generally supposed to be far the most influential in the ranks of the clergy of the present day. [CONCORDAT.]

As to ultramontane jurists, see Savigny, *Hist. of Roman Law*, vol. vi.

Ulva (Lat.). A genus of *Algæ*, typical of the *Ulvaceæ*, and distinguished from *Porphyra* principally by its green colour. The most familiar species is *U. latissima*, which, from its being frequently attached to oysters, is called *Oyster Green*. This and *U. Lactuca* are sometimes eaten like true Laver, under the name of *Green Laver*. It is also used occasionally in Scotland as a sort of water-dressing bound round the temples, by way of remedy in cases of headache.

Ulysses. The Latin name of the hero who is called ODYSSEUS in the Homeric poems. This name, in the opinion of some mythologists, represents the Sanscrit Urukshaya, and the Greek εὐρυκρείων, *wide-ruling*.

Umbel. In Botany, a form of inflorescence in which all the pedicels proceed from a single point. If there is no subdivision, the umbel is called *simple*; but if the pedicels produce other umbels, as in Parsley, the umbel is *compound*.

Umbelliferæ (Lat. umbella, dim. of umbra, *a shade*). A natural order of epigynous Exogens, the species of which abound in all cool or temperate climates, and even occur in hot ones, though much more rarely. They are known in general by their flowers being disposed in an umbel. They have an herbaceous stem; leaves usually much divided, often inflated when they join the stem; and they have universally a dry fruit, which always separates into two dry one-seeded carpels or *mericarps*, resembling seeds, which indeed they are popularly but erroneously called. The real seed is inside, closely adhering to the outer pericarp: it has a minute embryo in the base of the horny albumen. The mericarps are furnished with a definite number of raised longitudinal ribs, and underneath the intervening channels are frequently placed elongated receptacles for essential oil, called *vittæ*, remarkably constant in each species in their number and position. It is chiefly from the arrangement of these ribs and vittæ, and from the shape of the enclosed albumen, that modern botanists have derived the characters by which the numerous genera of *Umbelliferæ* are distinguished.

Some of the species are poisonous, as Hemlock and Water Dropwort; others are esculents, as Celery, Carrot, and Parsnip; many yield aromatic fruits, as Caraway, Coriander, and Anise. A few of them secrete a fetid gum resin, of which Assafœtida, Ammoniacum, and Galbanum are examples. The species are very numerous, nor is it easy to recognise them with accuracy; and, unfortunately, no general rule has yet been discovered for distinguishing the poisonous from the harmless kinds.

Umber. Two distinct substances are used as pigments under this name. One is a variety of Peat or Brown Coal, large beds of which are worked near Cologne, and which is said to be largely used in the adulteration of snuff; the other, called *Turkish Umber*, is a variety of ochreous Iron-ore (Limonite) composed, according to the analysis of Klaproth, of 48 per cent. of peroxide of iron, 20 peroxide of manganese, 13 silica, 5 alumina, and 15 water. The term

Umber is said to be derived from Ombria or Spoleto, in Italy, where it was first obtained. It is also found near Castletown in the Isle of Man, and fine pigments are also made from the Umber which is procured in the iron mines in the Forest of Dean in Gloucestershire.

Umbilic (Lat. umbilicus). The umbilic of a surface is a point at which the normal sections have all the same radius of curvature. The curvature of the surface at such a point is said to be *spherical*. A surface of the n^{th} order has in general a definite number of umbilics, the methods for finding which are given in most text-books. A curve on the surface, every point of which is an umbilic, is called a *line of spherical curvature*. [CURVATURE.] An ellipsoid has four umbilics, each of which is in the plane of the greatest and least axes at a distance from the centre equal to the mean semi-axis. [CONFOCAL AND CONCYCLIC QUADRICS; CURVATURE, LINE OF.]

Umbilical Cord. In Anatomy, the cord-like prolongation of the teguments of the abdomen, including the vessels which pass from the fœtus to the placenta in placental mammals: or to the allantois and vitellicle in implacental mammals, birds, and reptiles; or to the vitellicle alone in plagiostomous fishes. In other fishes, in batrachians, and in most invertebrates, the vitellicle is sessile, and there is consequently no umbilical cord.

UMBILICAL CORD. In Botany, an elongation of the placenta in the form of a little thread, by which the seeds are sometimes attached, as in the hazel pea.

Umbilical Focal Conic of a Quadric Surface. The locus of point-spheres (umbilical foci), each of which has double contact with the quadric of such a nature that the planes of contact (and intersection) are real. These planes are always parallel to the circular sections of the quadric, and the umbilics of the quadric are clearly points in the locus; hence its name. [FOCUS.]

Umbilical Vesicle. The name given to the proportionately small vitellicle, or yolk bag, in man and most mammalia.

Umbilicate (Lat. umbilicus, *a navel*). In Zoology, when a pit, tubercle, or granule has a depression in its centre.

Umbilicus (Lat.; Gr. ὀμφαλός). This word signifies properly the navel: hence it was metaphorically applied to the two ends of the roller on which the manuscripts of the ancients were rolled, and which were usually adorned with ornamental knobs, while the ends of the parchments were filed with pumice-stone, in order that the folds might lie smooth and neat.

UMBILICUS. In Botany, the scar by which a seed is attached to the placenta, frequently of a different colour from the rest of the seed, and not uncommonly very dark-coloured. It is more commonly called *hilum*.

UMBILICUS. In Conchology, the aperture or depression in the centre, round which the shell is convoluted.

UMBILICUS. In Geometry, this term is used by the older geometers synonymously with focus.

Umbo (Lat.). A protuberance or boss. In Conchology, the point of a bivalve shell immediately above the hinge.

Umbonate (Lat. umbo, *a boss*). In Botany, this term is applied to parts which are round, with a projection in the centre, like the boss or *umbo* of an ancient shield; as the pileus of many species of *Agaricus*.

Umbra (Lat. *a shadow*). In Astronomy, this term is applied to the dark cone projected from a planet or satellite on the side opposite to the sun. [ECLIPSE.]

Umbraculum (Lat. from umbra). In Botany, a term applied to those convex bodies which in *Marchantia* terminate the seta, and bear the reproductive bodies on the under side.

Umbræ (Lat. *shades*). In Roman domestic life, a name given to uninvited guests brought by one who was invited.

Umbral Notation. An invention of Prof. Sylvester's by which quantities are represented by combinations of letters, or *umbræ*, which, taken separately, have no meaning. For DETERMINANTS, the notation is very convenient and frequently employed.

Umbrella (Lat. umbraculum, from umbra, *a shade*). In Asiatic countries, the umbrella has from time immemorial been regarded as the special ensign of royalty. As such it is used as a termination to the Buddhist topes, and the Hindu pagodas, which are all of the conical form. [LINGA; ROUND TOWERS; TEMPLE.] The umbrella so used is called a *tee*. Originally they seem in all cases to have been of wood. An example still exists in the cave of Karli, which Mr. Fergusson (*Handbook of Architecture*) thinks may possibly be the very umbrella first set up 1800 years ago. Sometimes three umbrellas were placed one over the other; and when, following the ordinary course of developement, they came to be copied in stone, a more complete architectural character was given to them, until at last they assumed something of a spire-like form. In the *tee* or tope-finial, Mr. Fergusson sees the model of all Chinese buildings; but, on the other hand, it is urged that a mere piece of detail, insignificant in size, could scarcely have been taken as the type of whole buildings and repeated with astonishing perseverance and monotony, as the domestic designs of the Chinese follow manifestly the same model with the *taas*, or pagodas, while if we regard the tent of the nomad as the original type of both, we at once have the clue to the baseless post without capital or entablature, to the projecting concave roofs and the curved spikes which fringe it, the pagoda being simply the repetition of one tent on another until it reaches the height required. (*Edinburgh Review*, January 1857, p. 124.)

Umpire (this word is thought by some to be derived from the Fr. impair, *uneven in number*, an umpire being a third party to whom a dispute is referred; while by others it

is referred to the Lat. imperium, *a command*). An umpire is properly a person whom two referees, each chosen by his client, being unable to agree, jointly choose to determine between them.

Un. In English compound words, this is a particle denoting separation or negation. It corresponds to the Greek ἀν, as in ἀνώδυνος, *anodyne*, i.e. *without pain*, or *allaying pain*. In Latin, it answers to *in*, as in *inconstans*, inconstant.

Unarmed. In Botany, this term is applied to those parts which have no spines, prickles, or other sharp hard projections. It sometimes means pointless.

Unbend. In Sea language, to take the cable from the anchor, a sail from its yard, &c.; to untie one rope from another.

Uncaria (Lat. uncus, Gr. ὄγκος, *a curve*, hence *a hook*). This name was formerly given to a group of Cinchonaceous climbing plants with hooked spines, belonging to the *Cinchonaceæ*, one of which affords the astringent masticatory or tanning material called Gambir or Terra Japonica. It is now transferred to a genus of *Pedaliaceæ*, of which *U. procumbens*, the only species, is commonly known as the Grapple-plant at the Cape of Good Hope and in other parts of South Africa, on account of its very curious fruits being furnished on all sides with strong-branched very sharp hooks, by means of which they lay hold of the clothes of travellers or the skin of animals with singular tenacity. Dr. Livingstone says that when these fruits happen to lay hold of the mouth of an ox, the animal stands and roars from pain and helplessness.

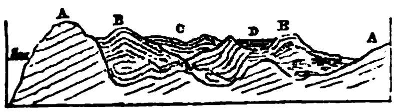
Unciæ (Lat.). The name given by the old writers on Algebra to the coefficients of the letters in the expansion of any power of a binomial. Thus, the expansion of $(a+b)^4$ gives $a^4+4\,a^3\,b+6\,a^2\,b^2+4\,a\,b^3+b^4$, in which the numbers 1, 4, 6, 4, 1, are the *unciæ*, or coefficients.

Unciales Literæ (Lat.). Uncial letters or writing. In Diplomatics, a species of character compounded between the capital and the minuscule or small characters; some of the letters resembling the former, others the latter. It is supposed to have been employed in Latin MSS. as early as the third or fourth century, but was seldom used after the tenth.

Unciform Bone (Lat. uncus, *a hook*). The last bone of the second row of the wrist bones; so called from its hook-like process in man, which projects towards the palm of the hand, and gives origin to the great ligament which binds down the tendons of the wrist.

Unconformable. In Geology, rocks are said to repose unconformably on one another when the lower rock has been removed from its original horizontal position, or has been denuded and its surface altered, before the overlying bed was deposited upon it. This condition is very common. It is illustrated in the accompanying diagram, where A A represents underlying rocks elevated at an angle of thirty degrees, and greatly denuded. The rocks B repose unconformably on A, and C again with equal want of conformability on A and B.

There may be absence of continued and unbroken succession even when there is no want



of conformability, while there may be apparent unconformability where the beds were really deposited in succession. This may arise in the first case from the fact that there had been no denudation in the exact spot where the beds are now laid bare, so that, although there has been great change and a long interval, there is orderly succession. The other case occurs when, owing to some local cause, or to the prevalence of different marine currents, parts of a deposit are swept away while other parts are being covered. In this case, although no perceptible or important interval has elapsed, and the rocks are strictly contemporaneous, they cease to be conformable in the strict sense of the word.

Unction, Extreme. [EXTREME UNCTION.]

Undecagon. [HENDECAGON.]

Underrun. In Sea language, to pass a boat or ship under a cable or rope, raising the latter above the surface for the purpose.

Undershrub. In Botany, the designation of a woody plant of small size, the ends of whose branches perish every year.

Understanding. A name given to that faculty by which man derives ideas from sensations. The impressions received from the outward world by means of the senses are regarded as the basis of all knowledge, and a creature destitute of perception would be incapable of learning or understanding. According to Aristotle, the one sense which is an indispensable condition for the acquisition of knowledge is that of touch. To the ideas formed immediately from perception, he gave the name of *phantasms*, this power of perceiving being the imagination, which with memory constitutes the whole intellectual nature of brutes, while in man it furnishes only the groundwork for the operation of the intellect, which, working on these sensations, reaches first simple and then more complex and general notions. The knowledge thus gained is wisdom; but wisdom as relating to things not concerned with ordinary practice is σοφία, when it regards practice only it is φρόνησις, the quality of both being the same, the difference lying only in the subject-matter. For the connection of the intellect with the soul, see SOUL and THEOLOGY.

Undertow. A current below different from that at the surface.

Underwood. The low woody growths produced among timber trees, sometimes called *coppice wood*, though the term *coppice wood* is more especially applied to woods in which

low growths of shrubs, or the stools of trees, are more abundant than timber trees. [COPPICE WOOD; STOOL.]

Underwriter. Up to the year 1824, all insurance companies, except two which were chartered (the Royal Exchange and London), were prohibited from negotiating marine insurances. The two companies in question, being possessed of a legal monopoly, levied such high rates of insurance, and exercised so rigorous a selection of vessels and voyages, that their business became next to nothing, and the whole system of marine insurance fell into the hands of individuals.

The persons who undertook this important duty, held their sittings just as the Stock Exchange did, at a coffee-house in the city, kept by one Lloyd, and became gradually known as Lloyd's. They could not legally enter into any joint-stock action, since the chartered companies could prohibit such action; and therefore when a merchant or shipowner wished to insure vessel or freight, he negotiated apparently with individuals only, who (acting of course in common) subscribed or *wrote under* the policy of insurance the sums for which they severally bound themselves, in case the ship or cargo were damaged or lost. The association of subscribers to Lloyd's established agencies in most of the principal ports, partly to carry out their business, partly to guard against fraudulent or excessive claims.

When the monopoly of the chartered companies was threatened, the underwriters were alarmed at the risk which they thought they would run from open competition, and employed all the means in their power professedly to bolster up the old monopoly of the two companies, but in reality to deter joint-stock enterprise. These endeavours failed, but the traditional system of underwriting still prevails, though co-ordinately with the establishment of companies which make it their business to grant marine insurances. (*Com. Dict.* 'Abandonment,' 'Average,' 'Jettison,' 'Marine Insurance.')

Undines or **Ondines** (Lat. unda, *water*). The name given by the Cabalists to one class of their spirits of the elements, viz. those residing in the waters. The ancient Greeks believed springs and lakes to be haunted by a race of supernatural nymphs [NAIADS]; and this belief passed down to the middle ages. The Saxons adored the female deity of the Elbe; and the belief in undines is scarcely eradicated in that region. The Saxon peasants report that an undine is often met in the market-place of Magdeburg, dressed as a girl of their own class, but always to be known by having one corner of her apron wet. Near Toulouse many objects of value were once discovered on draining a large artificial lake, which are supposed to have been thrown in as offerings to the spirits of the water. The *nix* of the northern countries and the Scottish *kelpies* belong to the same class of imaginary beings. This superstition has furnished the groundwork of Fouqué's beautiful tale, *Undine.*

Undue Influence. The use of undue influence at parliamentary elections, by intimidating, &c., voters, is now a substantive offence, punishable by a fine of 50*l.*, besides being a ground for avoiding the election. (Stat. 17 & 18 Vict. c. 102 and amending Acts.)

Undue influence exercised by parents over children, &c., is also a ground in equity for rectifying or setting aside dispositions of property and other legal transactions.

Undulation, Point of. In Geometry, a point at which a curve is met by its tangent in four consecutive points. This tangent, therefore, is a triple tangent with coincident points of contact. To the eye such a point presents no singularity, for the curve does not, as at a point of inflexion, there cross over to the other side of the tangent. A point of undulation of higher order is one at which the curve is met by its tangent in any *even* number of consecutive points.

Undulatory Theory. In Optics, the hypothesis according to which the impression of light is conveyed to the eye by the undulations of an elastic medium. This theory supposes the universe to be filled with an ether or medium of great elasticity, but so extremely rare as to offer no appreciable resistance to the motions of the planets. For an explanation of the phenomena of light and colours according to this theory, see LIGHT.

Uneven Number. In Arithmetic, the same with *odd* number; a number not divisible by 2.

Unformed Stars. In Astronomy, such stars as are not included in any of the constellations.

Unguiculate (Lat. unguiculus, dim. of unguis, *a claw*). In Botany, a term exclusively applied to petals which have an unguis or stalk.

Unguiculates (Lat. unguis, *a claw*). The name of a primary division of the gyrencephalous Mammalia, including those which have the digits armed with claws, but free for the exercise of touch upon their under surface. [MAMMALIA.]

Unguis (Lat.). In Botany, the narrow part or *claw* of the base of a petal, taking the place of the footstalk of a leaf, of which it is a modification. *Unguis* is also used as a term of measure equal to a nail, or half an inch, or the length of the nail of the little finger.

Ungula (Lat. *a hoof*). In Geometry, a solid formed by cutting off a part from a cylinder, cone, or other solid of revolution, by a plane passing obliquely through the base. The ungula is, consequently, bounded by the plane of the base, the intersecting plane, and the portion of the surface of the cylinder, &c. included between them. The name is derived from its resemblance to the hoof (ungula) of a horse.

Ungulates (Lat. ungula). The name of a primary division of the gyrencephalous Mammalia, including those species which have

the digits enclosed in hoofs, the under surface not being left free for the exercise of touch. [MAMMALIA.]

Unicorn (Lat. unicornis, from unus, *one*, and cornu, *horn*). The beast called *unicorn* in our version of the Old Testament (Heb. rem), is now commonly understood to be the rhinoceros. But the fabulous unicorn, which has passed into Heraldry, is represented with the figure of a horse, and a single horn issuing from its forehead. The unicorn of Pliny, however, has the head of a hart, the feet of an elephant, the tail of a boar, while the rest of the body resembles a horse. Aristotle, Ælian, and all the classical writers on animals, mention the unicorn. The traveller Ludovicus Romanus asserts that he saw *two* unicorns, kept alive in the temple of Mecca. Many strange virtues were attributed of old to the horn of the unicorn, particularly against poison; but the horns preserved in collections, and to which that name was given, belonged either to the rhinoceros, or to the narwhal or sea-unicorn.

Unicorn Root. The root of *Helonias dioica*, used in North America as an anthelmintic.

Unicursal. In Modern Geometry, a plane curve is said to be *unicursal* when its points can be determined individually, i.e. when the co-ordinates (x, y, z) of each point thereof are proportional to rational and integral functions of a variable parameter θ. Such a curve has the maximum number of double points, viz. $\frac{(n-1)(n-2)}{2}$, where n is its order. The term *unicursal* is due to Prof. Cayley, and is a very convenient one. (*Proceedings of the London Mathematical Society*, Oct. 1865.) Prof. Cayley also employs the term *deficiency* of a curve, to indicate the difference between the number of its double points and the above maximum number. *A unicursal curve*, therefore, *has no deficiency*.

Uniformity (Lat. uniformitas). In the Fine Arts, resemblance in shape between the correspondent parts of a subject.

Uniformity, Act of. In English History, the first Act of Uniformity is 1 Eliz. c. 2; the Act at present subsisting being 13 & 14 Ch. II. c. 4. It regulates the form of public prayers, administration of the sacraments, and other rites of the church of England.

Unigenitus (Lat.). The celebrated constitution, in the form of a bull, issued by Pope Clement XI. in 1713, in condemnation of Père Quesnel's *Réflexions Morales sur le N. Testament*. It is so called from its beginning, *Unigenitus Dei Filius*. Father Quesnel was a friend of the celebrated Jansenist leader Arnauld, and became chief of that religious party after the death of the latter. He died in exile at Amsterdam, in 1679. The bull was procured by the Jesuits, and especially by Le Tellier; it condemned 101 propositions selected from Quesnel's work. Its publication created great discord in France. Most of the bishops accepted it, but with explanations which they gave to the public. Cardinal de Noailles and others refused to accept it all. As soon as the duke of Orleans became regent, Le Tellier was banished, and the party opposed to the bull came into power; but the strength of Rome prevailed, and eventually the duke of Orleans himself compelled De Noailles to accept the bull in 1720. After that event the Janseuist party survived only in small fragments, chiefly among the commonalty of Paris. [JANSENISTS.]

Unilocular (Lat. unus, *one*; loculus, dim. of locus, *a place*). In Botany, seed-vessels not separated into cells. In Conchology, shells which are not divided into chambers.

Unimodular (Lat. unus, and modulus, *a measure*). In Algebra, a term applied to certain transformations and substitutions. [LINEAR TRANSFORMATIONS.]

Union (Lat. unio, *unity*). In British History. The union of the crowns of England and Scotland took place on the accession of James I. to the former. The scheme of uniting the kingdoms was afterwards several times taken up; and commissioners were appointed to consider the subject in the reigns of Charles II. and James II. It was finally carried into execution in 1706, the statute passed on that occasion being the 5 Anne c. 8. By this enactment, laws relating to trade, customs, and excise were to be the same in both countries; other laws to remain in force in each respectively. The parliament of the United Kingdom, called Great Britain, was to have 16 Scottish peers, and 45 members of the House of Commons. The mode of election of peers was subsequently regulated. [PARLIAMENT.]

The union of Ireland with Great Britain was proposed by Mr. Pitt immediately after the suppression of the rebellion of 1798, and it was carried into effect in 1800 by the statute 39 & 40 Geo. III. c. 67 of the British, and 40 Geo. III. c. 38 of the Irish statutes. It admitted 4 Irish lords spiritual, 28 temporal, and 100 commoners to the united legislature; the lords temporal elected for life, the lords spiritual sitting by a certain rotation. By article 5 the churches were united. For the changes which have since taken place in the number of Scottish and Irish members in the House of Commons, see PARLIAMENT.

Union Jack. In Heraldry, the national flag of Great Britain and Ireland. The ancient English flag was the banner of St. George (argent, a cross gules). On the personal union under James I. the banner of St. Andrew (azure, saltier argent) was added (1606). The flag adopted by the heralds after the legislative union (1707) is blazoned azure, a saltier argent surmounted by a cross gules edged of the second. The banner of St. Patrick (argent, a saltier gules) having been added on the union with Ireland, the present flag was thus compounded. It now consists of a red cross of St. George, a red diagonal cross, and a white diagonal cross; the last two being side by

side. The whole are on a blue ground. In addition to being used as an independent flag, it forms the upper quarter next the mast of the red, blue, and white ensigns.

Unions, Trades'. [COMBINATIONS; TRADES' UNION.]

Unionite. The name given to a white Lime-Epidote resembling Soda-Spodumene in general appearance, after the locality, Unionville in Pennsylvania, where it occurs.

Unipeltates (Lat. unus, *one*, and pelta, *a buckler*). The name of a family of Stomapodous Crustaceans, comprehending those in which the carapace is composed of a single shield-like plate.

Uniplanar Node. [NODE.]

Unison (Lat. unus, *one*, and sonus, *sound*). In Music, a consonance of two sounds equal to each other in gravity or acuteness, i.e. sounding the same note.

Unit, Unity (Lat. unitas). In Arithmetic, the number one; an individual of discrete quantity. Euclid defines number to be a multitude or collection of units.

Unit Coil. *Unit of electrical resistance.* A standard measure used by electricians for expressing the amount of resistance experienced in a given electrical circuit.

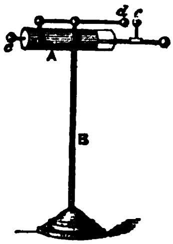
When comparing different electrical circuits, it is as important to be able to reduce the different resistances to terms of some one unit as it is necessary to have one unit of weight and length. One of the earliest units of electrical resistance was that employed by Lenz, who adopted 1 foot of copper wire of a known thickness. In 1843 Wheatstone proposed 1 foot of copper wire weighing 100 grains as a unit. This proposal was succeeded by others from scientific men abroad, each one being founded upon the national weight and length.

The intercommunication and extension of electrical knowledge which followed the introduction of telegraphic wires and submarine cables, rendered it necessary to have some one generally accepted electrical standard as the recognised measure in every country.

To determine what the standard should be, at Prof. W. Thomson's suggestion, the British Association in 1861 appointed a representative committee. This committee agreed upon a system of electrical measurement first proposed by M. Weber, and having many decided advantages. The British Association unit is expressed in ordinary measures, the French being chosen for more general acceptance; and from it can be derived not only the electrical resistance, but the electro-motive force of the current and its equivalent of work.

The unit is known as the B.A. unit, or Ohmad; and is about equal to the mercury unit previously used by Siemen, which is the resistance of a column of mercury 1 mètre long and 1 square millimètre in section at a temperature of 0° C. The B.A. electrical standard is not, however, in general, made of mercury, but of a thick insulated wire, formed of German silver or an alloy of platinum and silver, about 5 feet long, wound into a coil round a hollow bobbin, and the whole covered with an insulating coat of solid paraffin. Precisely to define the B.A. unit is a matter of some difficulty even among electricians, and impossible in a short and general notice like the present. For such a definition and further information, we would refer the reader to Mr. Fleeming Jenkin's report on the new unit, published in the *Proceedings of the Royal Society* for April 1865. A full and popular explanation of *electro-magnetic units* will also be found in Dr. Ferguson's recent and excellent little treatise on *Electricity.*

Unit Jar. A small insulated Leyden jar used for measuring definite quantities of electricity. This instrument was devised by Sir W. Snow Harris, and consists of a small glass jar A, coated inside and outside with tinfoil, and mounted horizontally on a glass rod, B. Attached to the brass wire which connects the inner coating of the jar with an electric machine is a sliding brass ball, *c*. The electricity repelled from the exterior coating is conveyed into the surface to be charged from the ball *e*. When the unit jar is charged to a certain amount, determined by the distance apart of the balls *d c*, a spark passes between *d* and *c*, and discharges the little jar; but being again recharged by the machine, another spark ensues, and so on. By counting the number of sparks and noting the distance between the balls, the number of equal but arbitrary units which have been repelled from the outer coating on to a larger surface (as a large Leyden jar or battery) may be ascertained.



Unitarians. Those who confine the Godhead to a single Person; in which general sense the term may be taken to represent the Arians and Socinians, as well as the sect which is more strictly denominated Unitarian. These last are the descendants of the religious communities which adopted, in the sixteenth century, the opinions of Socinus. They have been supplied with converts from the Presbyterians and Independents in this country, many congregations of whom became first Arian, and latterly Unitarian in sentiment. The principal Unitarian authorities are Drs. Priestley, Belsham, and Channing, who, rejecting the ordinarily received doctrine of the atonement, represent the language ascribed to the apostles upon this and other points as either intentionally accommodated to the ideas current among their hearers, or derived from erroneous conceptions of their own. The Unitarians were subjected to severe penalties, as deniers of the Trinity, long after other dissenters had been relieved by the Act of Toleration: the laws against them were not repealed by statute till the year 1813.

In this country, where they do not constitute

a numerous body, they are principally composed of persons of the educated classes. In Geneva the pulpits of the established church are mostly occupied by professors of these opinions, and in the northern states of America they form an influential Christian denomination.

Unitary Notation. [NOTATION.]

United Brethren. In Ecclesiastical History, a body of reformers in Bohemia, who separated themselves from the Catholics and Calixtines (according to some writers) about 1467. It is also said that they received episcopal ordination from the Vaudois. According to others (Bossuet, *Variations des Eglises Protestantes*, ch. ii.), they were an offshoot from the TABORITES or THABORITES. At all events, it appears certain that there already existed a considerable body of persons professing the tenets of the Reformation in Bohemia at the period of Luther.

United States. It would be inappropriate in this work to give any account of the geographical peculiarities, or of the commercial growth and position, of the United States. For these subjects, the reader may be referred to the *Geographical Dictionary* and the *Commercial Dictionary*. But it appears desirable to say a few words on the constitution of the American republic, and especially on those parts of the constitution the interpretation of which has been, and still is, the subject of earnest debate, and furnishes the material for political action.

The constitution of the United States is written. It may be said, that in general terms the purpose of its framers was the establishment of a political unity in the intercourse which the states might have with other nations, and of domestic independence in the various communities which formed the Federal Union. Great discretion was accorded to the states, in regard to municipal ordinances. They were empowered to contract debts at their discretion; to determine the rights of citizenship; to modify civil rights, as those of marriage, divorce, and the privilege of devising and settling land; to impose internal taxes; and the like. But they were restrained from having an independent army or navy, from imposing import or export duties, and in general from those privileges which have been called *imperial*. [STATE RIGHTS.] It was probably felt that the cohesion of the several states, composed as they were, at and after the War of Independence, of such various, and generally of such discordant, elements, was a matter of great uncertainty, unless the fullest freedom were given to the contracting communities.

Every constitution, even if it be merely traditional, and therefore distinguished only by broad lines, needs an interpreter. But a written constitution, like a dogmatic confession of faith, invites scrutiny and criticism, is sure to be variously understood whenever interests are conflicting, and is certain to be strained when any political party is eager and able to administer it. The difficulties which belong to a traditional constitution are sure to be exaggerated when the institution is defined by positive enactments, especially when those enactments were compromises, forced on the contracting parties for common ends and by common dangers. The prospect of these differences and difficulties has always been present to the American people, who have thereupon treated the constitution with an almost superstitious reverence. No one, however, could have doubted, that at some time or other conflicts would arise between the Northern or free states, and the South or slaveholding communities, although the former were patient under the continual political ascendency of the South, and the latter did not, except on rare occasions, quarrel with or contest the protectionist policy of the North. It was easy, however, to foresee that the apparent harmony of the states was only an armed truce, and that sooner or later dissension would break out; nor was it difficult to predict that this hostility would take the form of a struggle between the slavery and the free-soil parties. As we know now, these differences culminated in the election of Mr. Lincoln, i. e. in the total defeat of the party which desired to extend slavery into the territories, in the secession ordinances of 1861, and in the four years' war.

The difficulties, however, which attend the interpretation of the American constitution have only now begun. The party of amnesty, i. e. the Democrats, and the party of reconstruction, i. e. the Republicans or Radicals as they are now called, equally appeal to the written constitution, as supporting courses of policy diametrically opposed to each other; and as the differences are not speculative, but practical, the decision arrived at at last can scarcely fail to put so new an interpretation on the terms of the document which constitutes the Union, as to make the gloss, whatever it be, a new clause or a new set of clauses in the instrument itself. One thing at least is certain, that the congress will henceforward assume a far more important position in the public life of the American people, and that it will tend more and more to dwarf and curtail those state rights the independence of which has formed so singular a characteristic in the American federation. The reconstruction of the Southern states is in effect the reconstruction of the Union, since it is hardly possible to impose conditions on those communities without implying a similar supervision over the municipal arrangements of the other states. Nor is it likely that the supreme court, with which rests ultimately the decision as to the legality of acts, and their accordance with the constitution, will oppose a permanent or effectual barrier to the purposes of the successful parties in that great civil struggle which has succeeded to the civil war; for it may be laid down as a general maxim in politics, that judicial opposition may retard, but can never arrest, political changes.

Unities. In the Drama, there are said to be three unities—of time, place, and action.

The latter only is strictly adhered to in the Greek drama; but the drama termed *classical* by the moderns (in opposition to the *romantic*) requires all three. [DRAMA.]

Univalve (Lat. unus, *one*; valva, *a valve*). This term is applied to those Molluscs the shell of which is composed of one piece, and which is generally convoluted spirally. Latreille also thus denominates a family of Lophyropodous Crustaceans.

Universal (Lat. universalis). In Logic, a universal proposition is that which has the subject distributed, so that the predicate is declared concerning everything comprehended in it; e. g. 'All men (subject) are mortal (predicate).' In universal negative propositions the predicate is distributed also; e. g. 'No men are immortal.' For the nature of Universals, see LOGIC, PROPORTION, SYLLOGISM.

Universal Joint or **Hooke's Joint.** In Machinery, an ingenious contrivance of Dr. Hooke, for the purpose of enabling the end of a shaft or suspended rod to be moved in any direction as freely as if the junction were by a ball-and-socket joint, while the shaft will nevertheless be able to communicate through the joint the force of torsion. The universal joint is virtually two hinges set in the same plane, one of which permits motion in one direction, and the other in a direction at right angles thereto; and by the combined motion of the two, the end of the shaft or rod may be made to describe a circle or any other figure. By this expedient, connected lengths of shafts may be made to rotate, though they are not in the same right line. The universal joint is either single or double. In the single universal joint, the two shafts or axles, A and B, between which the motion is to be communicated, terminate in semicircles, the diameters of which are fixed in the form of a cross, their extremities moving freely in bushes placed at the extremities of the semicircles. Thus, while the central cross remains unmoved, the shaft A and its semicircular end may revolve round CD as an axis; and in the same manner B, with its semicircular end, will revolve round E F. If the shaft A be made to revolve without changing its direction, the point C D will move in a circle whose centre is at the middle of the cross. The motion thus given to the cross will cause the points E F to move in another circle round the same centre, and hence the shaft B will be made to revolve.

Fig. 1.

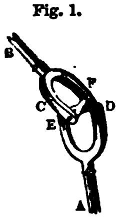


Fig. 2.

When the shafts are inclined to each other under an angle of 40°, it is necessary to employ a double universal joint, as represented in the annexed figure. In this manner the motion may be transmitted from one shaft to another at right angles. Instead of employing a cross in the manner now described, the joints may be constructed with four pins, fastened at right angles upon the circumference of a hoop or ball. Universal joints are of great use in cotton mills, where the tumbling shafts are continued to a great distance from the moving power; for, by applying a universal joint, the shafts may be cut into convenient lengths, and so be enabled to overcome a greater resistance.

Universal Language. More than one attempt has been made to contrive a system of writing that should be universally intelligible. As this writing would represent sound, the sounds, if uttered, would form a universal language. But the latter purpose is not necessarily involved in the former. The best known effort of the kind is perhaps that of Bishop Wilkins, who asserted that 'if to every thing and notion there were assigned a distinct mark, together with some provision to express grammatical derivations and inflexions, this might suffice as to one great end of a real character—namely, the expression of our conceptions by marks which shall signify things and not words.' It follows that a universal classification must precede the formation of such universal language, and to have any value this classification must be permanent, i. e. it must not need alteration owing to the acquisition of new information; in other words, universal knowledge seems to be an indispensable condition for the formation of universal language. Such attempts may therefore be regarded as the efforts of men sitting in judgment on the whole realm of human knowledge and dreaming that they have mastered it. The classification proposed by Bishop Wilkins is given by Prof. Max Müller in his second series of *Lectures on Language*, ii.

Universalists. A name by which the Arminians are sometimes characterised, as expressing the universality which they attribute to the operation of grace, conceiving it to be given to all men without favour or reserve. On the other hand, the Calvinists, or those who hold the particular election of individuals, are designated as Particularists. The name is also applied by some to those who maintain that as God desires the highest welfare of all His creatures, so He will ultimately bring them to it.

University. In the middle ages, the Latin term *universitas* signified the whole body of students, or of teachers and students, assembled in a place of education, with corporate rights, and under by-laws of their own; in later times, also, the name was held to imply that all branches of study were taught in a university. In the modern sense of the term, a university signifies an establishment for the purposes of instruction in all or some of the most important divisions of science and literature, and having the power of conferring certain honorary dignities, termed *degrees*. It is generally understood that the authorisation of the sovereign power in the state is necessary to enable such an establishment to confer degrees; and, in most European countries, there are various offices and

professional situations for which a person is qualified by having taken a certain degree at one of these establishments. Hence universities, although in many instances they are composed of private foundations, are justly regarded as national institutions. The university of Paris, the most celebrated of those of the middle ages, and which served in some degree as a model to the rest, was formed about A. D. 1200 by the union of the various schools of rhetoric, theology, and philosophy, with which that city abounded, under one head, styled the *rector*. That university was divided into four nations—French, Picard, Norman, and English: the first comprehending students from Italy and Spain, the last from the north of Europe generally. The subjects taught were arranged under faculties; viz. theology, law, medicine, and that of the seven liberal arts, rhetoric, logic, grammar, geometry, arithmetic, astronomy, music. [QUADRIVIUM; TRIVIUM.] These faculties were corporate, and each elected a dean; and the deans, with the procuratores of the nations, represented the university. The lowest degree was that of *bachelor*; the next, *licentiate*; the third, *magister* (this degree at Paris corresponding with that of *doctor* at Bologna). The colleges were royal or private foundations for the benefit of poor students, whose board was, in some instances, found for them, and who received stipends or other emoluments. The faculty of theology at Paris was well known by the name of the SORBONNE. This slight sketch of the constitution of the famous university of Paris may serve to describe similar establishments in Continental countries during the middle ages, and down to a comparatively late period. In England, the two national universities have been established, from a period of considerable antiquity, at Oxford and Cambridge. The original constitution of these universities much resembled that of the Parisian, with the exception of the division into four nations, which was wanting. But their subsequent history was modified by the growth of the colleges, or individual foundations, into a much higher degree of consequence. These were originally destined by their founders merely to entertain a certain number of junior students (generally termed *scholars*), and a higher body (named in most cases *fellows*), and to furnish them with assistance in the prosecution of their studies; while the great body of independent students lodged in the numerous halls, and attended only on the public university lectures. But by degrees the colleges likewise became receptacles for independent students, under the tuition of the fellows; the halls were for the most part abandoned, while such as remained partook of the collegiate character; and, in the modern system (which has subsisted for more than two centuries), no student is admitted to take a university degree unless he has completed his studies in a college, or collegiate hall, under the superintendence of its tutors. The degrees, in Oxford and Cambridge, are differently named, or arrived at in different succession, in the several faculties; but degrees in theology and medicine can be obtained only after the acquisition of certain degrees in arts.

In the English universities, as in those on the Continent, the industry of students has from an early age been aided by foundations, created by public or private munificence. The practice of endowing *exhibitions* or pensions for scholars (in mediæval Latin *bursæ*, whence the German bursche for a student), has been almost universal in Europe. Confining ourselves to the universities of Oxford and Cambridge, we find the following results. The several endowments established for the benefit of scholars may be classed either as *university* or as *collegiate*.

University Scholarships.—These are given, generally speaking, to students already established at the universities, as rewards of merit in classics, mathematics, divinity, and other special subjects. There are at present about 40 university scholarships at Oxford—about 25 at Cambridge—with emoluments varying from 75*l.* per annum (the Craven scholarships at both universities attain this sum) to inferior amounts. They are attainable for the most part by undergraduates, and are held only for a few years. There are also many exhibitions, attached to public and grammar schools, which are given after open competition to members of those schools on their departure for the university, to be held by them during a specified time, which is generally limited to the number of terms necessary for obtaining the first, or Bachelor's, degree in Arts.

University Fellowships are very few: the most remarkable, the Radcliffe *travelling fellowships* at Oxford, were created to advance the acquisition of classical and other knowledge through foreign travel.

But the collegiate endowments, for the benefit of students, are of far more importance than those which appertain to the university in general.

According to the ancient system, the founder of a college at Oxford or Cambridge, whether the crown or a private individual, endowed it with sufficient means to maintain a head (principal, master, warden, &c.), a certain number of fellows, and a certain number of scholars. These were appointed under an infinity of private statutes; preference (absolute or comparative) being given to persons educated at particular schools, natives of particular parts of England, *founders' kin*, and so forth. While in the lapse of time the foundations at Oxford retained their strictly exclusive character, those at Cambridge became more open; the ordinary rule at the latter university being that *scholarships* were open to the most deserving competitors, *fellowships* to the most deserving members of the college, unless the fellows thought proper to elect from the university at large. These ancient institutions were, however, remodelled after long and careful enquiries by commissioners, in the present reign. The collegiate foundations at Oxford are now governed by the statute 17 & 18 Vict. c. 84 (passed in

1854), and under the forms thereby given to the authorities of the several colleges. Cambridge is regulated by the body of university statutes, confirmed in 1858.

The general result, as regards foundations in the colleges of Oxford and Cambridge for the benefit of students, may be thus summed up. They are divided into—

1. *Sizarships, Servitorships, &c.*—Endowments especially for the benefit of poorer students; formerly connected with inferiority of position, which modern improved feeling has nearly removed.

2. *College Scholarships.*—These are very numerous in both universities, and are for the most part attainable by open competition, by students on their first admission to the university; lasting generally until the degree of B.A. or somewhat later: with endowments varying, according to the wealth of the several colleges, from nearly 100*l.* to much lower amounts per annum.

3. *Fellowships.*—The highest and most important order of college endowments. The number of these has been considerably reduced by recent reforms.

There are, at present, 385 fellowships in the colleges of Cambridge: about 350 at Oxford (including the senior studentships of Christ Church). The great majority of these are now attainable by open competition, by members of the university who have attained the degree of Bachelor of Arts. The exceptions at Oxford are chiefly that at New College some preference is given to persons educated at Winchester; and that at All Souls the competition is limited in a particular manner, which has formed the subject of a recent judgment of the Privy Council in favour of open competition (1864). The larger colleges at Cambridge still elect to fellowships by competition in their own body. The value varies from 300*l.* and upwards per annum, to much lower amounts. The tenure of fellowships was, until recent reforms, altogether confined to the unmarried, and chiefly to those who intended to adopt the clerical profession; but at Cambridge the general rule may now be said to be that fellowships last for ten years, and are not determined by marriage; each college, however, at both universities, has its own rules.

The university of Paris was suppressed in 1790. The present university of France was instituted in 1808, and embraces the whole empire. It is subdivided into twenty-seven academies, each governed by a *recteur* and *conseil académique*. In Spain, the universities are arranged on a system somewhat resembling that which prevails in England, the students being entered of their respective college in each. In Germany, as in England, the earliest universities (Prague, founded in 1348, and Vienna, in 1365) were framed on the model of that of Paris. Germany has now a far more numerous list of universities than any other country. But the collegiate system never prevailed in that country as among ourselves. On their present arrangement (which is pretty similar in all, Catholic as well as Protestant), the four faculties are retained. Professors in the various branches are appointed by government. These form the senate, at the head of which is the pro-rector, who is chosen annually or biennially. Besides these, there are extraordinary professors, who receive small salaries, and an inferior class of licensed teachers, or licentiates, who receive none. The professors are obliged to give public lectures in the branch of study to which they are appointed; but they, as well as the other two classes, may give also private lectures on whatever subject they please; and from the fees of attendance at these lectures their principal income is derived. The student is for the most part left at liberty to attend what lectures he pleases; but licenses to practise various professions, benefices in the various churches, &c. are given, especially in Prussia, only to those who have studied a certain number of years by attending lectures in the requisite branch of study. The constitution of the Scotch universities has a great resemblance to those of Germany; and the same remark is applicable to the London University. A great mass of information with respect to ancient and modern universities, will be found in the *Encyclopædia Britannica*, 8th ed. 1860, art. 'University.' See, too, Savigny, *Hist. of Roman Law*, vol. iii. For an elaborate defence of the English system, see *Quart. Rev.* vols. lii. lix.

Univocals or **Synonyms.** In the Aristotelian Logic (as used by the schoolmen), generic words; i.e. words of which both the genus and the difference are predicable of many different species; e.g. the genus *animal* is *univocum univocans* with respect to *man* and *brute*, both of which are comprehended under any definition which can be given of the word *animal*, and are called with reference to it *univoca univocata*. *Universal* terms are also such as have only one signification; opposed to *equivocal*.

Unproductive Consumption. In Political Economy, a term used by some writers to denote that expenditure which has no relation, either directly or indirectly, to the replacement of the capital employed on it. It may, of course, happen that consumption may be productive in one case, and the contrary in another. The idle amusements of this person may be the necessary recreations of that; the luxurious expenditure of some may be the business of others. Nor does it follow that unproductive consumption is an economical evil. The taste for enjoyments is an unquestionable stimulus to activity, and those communities make but little progress in wealth whose habits are rude, unrefined, and exceedingly parsimonious. But all waste which may be avoided is in a full sense unproductive consumption, whether it be waste of capital, waste of labour, or waste of life.

Unstable Equilibrium. [STABLE AND UNSTABLE EQUILIBRIUM.]

Upádána. In the Buddhist Theology, upádána (or the attachment to existence) forms

with karmma (*work*) the cause of all causes and the source from which all beings have originated in their present form. All beings are produced from the upádána of some previous being, while karmma is the aggregate action which by virtue of its existence it must produce. This is only another way of stating the doctrine of necessity; but instead of seeking happiness by ignoring a law confessedly inevitable and unknown, the Buddhist deduction is that the duty of man is to kill the law by uprooting the upádána or attachment to existence, all evil being produced directly from this cause. The object of the Buddhist philosophy is the attainment of perfect calm, in which the man may cease to be conscious of being. The state thus attained is nirwan, or nirvana, which some suppose to be absorption into the supreme all-pervading deity; others to be a mere nonentity, there being no supreme deity into which being may be absorbed. In this philosophy the idea of sin is inadmissible, everything being in itself indifferent, and the so-called badness of a thing being dependent entirely on the injury resulting from it to another. The practical result of such a system, if free from all judgments and drawbacks, would be a general passive benevolence, active well-doing being by the hypothesis of no use whatever. (R. S. Hardy, *Legends and Theories of the Buddhists*.)

Upas-tree (Upas, the Javanese name). A tree common in the forests of Java and some of the neighbouring islands, to which extraordinary stories, for the most part fabulous, have been attached. Upon the authority of Dutch writers, it has been asserted that it is a most deadly poison employed in the execution of criminals, who are, however, pardoned if they succeed in reaching a tree and bringing back its venom. Birds were said to drop dead while flying over it, and the whole country round it was asserted to be desolated by its pestilent effluvia. The truth is, that the Upas-tree is merely a tree with poisonous secretions, and nothing more; there is nothing deleterious in its atmosphere. It is an Artocarpaceous plant, called *Antiaris toxicaria*, and is very nearly related to the fig, some of the species of which are also deadly poisons. [ANTIARIS.]

Uphers. In Architecture, fir poles chiefly used in scaffolding; they run from twenty to forty feet in length, and from four to seven inches in diameter.

Uphroe. On Shipboard, an oblong block, without sheaves, and having several holes. Its use is to hold ropes temporarily extended: the formation preventing the rope from slipping.

Uplands. Lands on hills or steep declivities, which in general require a different kind of management from lands in plains or comparatively flat surfaces. Uplands are generally kept in pasture or underwood.

Upper Eocene. These beds are almost wanting in England. The Hempstead and Bembridge series of the Isle of Wight have recently been referred to them. In France, the Fontainebleau sands form the base, but the main developement is in a vast and varied series of fresh-water and lacustrine sandstones, marls, and millstone-rock. These occupy large tracts in Central France, especially in the Auvergne district, and also in the basin of the Rhine at Mayence and various points. The French deposits reach up to the valley of the Seine. The Limburg beds of Belgium are referred to the same division of the older tertiaries. Some of the German brown-coal is of this date.

Upper Greensand. A calcareous sandstone often coloured green by particles of silicate of iron, and often passing into hard clayey bands. As a characteristic rock deserving its name, it is confined to the south-east of England. In Surrey, parts of it are worked for lining furnaces and sold as *firestone*. A little farther west, it passes into what is locally called *Malm Rock*, and a rock of the same kind and the same age is seen at Blackgang Chine in the Isle of Wight, where it is 400 feet thick, the upper part cherty and the lower sandy. It is well seen in Dorset and North Wiltshire, but becomes less important as it is traced below the chalk in Bedfordshire and Cambridgeshire. It is rich in nodules of phosphate of lime. [COPROLITES.]

Upupa (Lat. upupa, Gr. ἔποψ, *a hoopoe*). A genus of Tenuirostral Passerine birds, distinguished by an ornamental head-crest formed of a double range of feathers, which can be erected at will. The common hoopoe (*Upupa epops*) is an occasional but rare visitant of England.

Urachus (Gr. οὐραχός). The ligamentous chord which arises from the base of the urinary bladder, and terminates in the umbilical chord.

Ural Mountains. This low chain, unimportant enough in some respects, is interesting as the only interruption to the level of the great northern plain of the Old World. It is entirely unconnected with the main chains of Asia, and may be traced from between the lake of Aral and the Caspian Sea, as far as the northern extremity of Nova Zembla in the arctic circle, a distance of nearly 2,000 miles. As a chain, however, it begins only in about 50° north lat. It is about the height of the Vosges mountains in Eastern France, and nowhere reaches 3,500 feet. It is wooded to the top, and is singularly rich in mineral wealth of all kinds, its gold, copper ores, and iron ores having long been extensively worked.

The Ural chain serves as the dividing line between Europe and Asia, but it rises so gently, and the passes across it are so low, as to be almost unnoticeable. Extensive marshes occur on the Siberian side. There are no precipices or gorges connected with it; but Sir R. Murchison describes some real mountain scenery not unlike that of Wales and Scotland in the part of the chain called the *Katchkanar*. The geological age appears to correspond.

Uralite. A pseudomorphous form of Hornblende after Augite, which is found in the augitic porphyry of the Ural.

Uralorthite. A variety of Orthite, found in the flesh-coloured Felspar of Minsk in the Ural.

Uramile. A white or pinkish crystalline body, the product of the decomposition of thionuric acid by heat. It contains $C_8 H_5 N_3 O_6$.

Uran-mica. [URANITE.]

Uran-ochre. [ZIPPEITE.]

Uranbloom. [ZIPPEITE.]

Urangreen. A native sulphate of copper and uranium, which is found in green acicular crystals and crusts at Joachimstahl in Bohemia.

Urania (Gr. οὐρανία). In the Hesiodic *Theogony*, Urania is mentioned as one of the nine Muses, the children of Zeus and Mnemosyné, and also as a daughter of Oceanus and TETHYS. For the meaning of the name, see URANUS.

URANIA. A synonym of *Ravenala*, a magnificent palm-like genus of *Musaceæ*, confined to Madagascar, where it is called the Traveller's-tree, because the leaves when cut yield an abundant and refreshing juice, with which travellers allay their thirst. The plant does not seem indigenous to Mauritius, as stated by some, but groves of it have been planted in the botanic gardens of that island. The leaves are of gigantic size, somewhat like those of *Musa Ensete*, but arranged in two rows on opposite sides of the arboreous stem.

Uranite or **Uran-mica.** Native phosphate of uranium and lime. It occurs nearly always in tabular crystals of a siskin-green to a yellow colour, and differs from Mica in being neither flexible nor elastic. Uranite is found in France at St. Yrieux near Limoges, and in Saxony.

Uranium. A metal discovered by Klaproth in 1789, who named it after the planet Uranus, discovered about that time. It occurs in the minerals *uranium ochre* $U_2 O_3 HO$; *pitchblende*, which consists of the black oxide $U_4 O_5$ associated with silica, lead, and iron; *chalcolite*, *uranglimmer* or *uran-mica*, which consists of the phosphate of copper and uranium, $Cu O$, $2 U_2 O_3$, $P O_5$, $8 H O$, and *uranite*, which is the phosphate of lime and uranium, $Ca O$, $2 U_2 O_3$, $P O_5$, $8 H O$.

Little is known of the properties of metallic uranium: it appears to be a slightly malleable whitish metal, of the specific gravity about 9. The salts of the oxides of uranium are of a green or yellow colour: the persalts have been most examined. Ferrocyanide of potassium produces in them a very characteristic rich brown precipitate, not unlike that formed by the persalts of copper. They are also precipitated brown by infusion of galls. Peroxide of uranium is used to give a green or greenish-yellow colour to glass, and a suboxide ($U_4 O_5$) is used in porcelain painting for the production of an intense black. The equivalent 60 has been assigned to uranium.

Uranochalcite (Gr. Οὐρανός, and χαλκός, *copper*). A Mineralogical synonym for Urangreen.

Uranoniobite. A name for the crystallised Pitchblende from Stromsheim in Norway.

Uranoscopus (Gr. οὐρανοσκόπος, *watching the heavens*). A genus of fishes was so called by Linnæus, because both eyes were placed on the superior surface of the head, which presents a nearly cubical form. The mouth is cleft vertically at the anterior part of the head, and, like the eyes, is directed upwards. The species of this genus commonly called *star-gazers* belong to the *Percoid* family of Acanthopterygian fishes in the Ichthyological system of Cuvier.

Uranus (Gr. Οὐρανός). In Astronomy, the remotest known planet, except Neptune, belonging to our solar system. The mean distance of Uranus from the sun is 19·18239, that of the earth being considered as unity, whence its real distance is upwards of 1,800 millions of miles. Its sidereal revolution is performed in about 84 Julian years. The orbit is inclined to the ecliptic in an angle of only 46′ 28·4″; and the eccentricity of the orbit is 0·046679, half the major axis being taken as unity. The apparent diameter of Uranus (which, on account of the great magnitude of its orbit in comparison of that of the earth, undergoes very little variation) is about 4″; whence the real diameter of the planet must be about 35,000 miles, or nearly four and a half times that of the earth; and its bulk about eighty times that of the earth. Uranus presents the appearance of a small round and uniformly illuminated disc, without rings, belts, or discernible spots. From analogy, we infer that it revolves about its axis; but of this there is no direct proof: the great distance of the planet, indeed, precludes our obtaining much knowledge of its physical state.

Only two satellites of Uranus are known with certainty, although the existence of four at least is suspected. [SATELLITE.]

Uranus was discovered by Sir William Herschel, at Bath, on March 13, 1781. It had been previously observed by Flamstead, Bradley, Mayer, and Lemonnière in their ordinary star-observations; but, owing to the inferiority of their telescopes, not one of these astronomers suspected it to be a planet. Sir W. Herschel called it the *Georgium Sidus*, in honour of George III. Foreigners for some time called it *Herschel*; and it is now, in some English works, called the *Georgian*. [PLANET.]

URANUS. In the Hesiodic *Theogony*, Uranus or Ouranos (the Latin Cœlus) is a son of Gaia, *the earth*; but he is also called her husband. This is, however, one of the names which had not lost for the Greek their original meaning. Ouranos is called by the Hesiodic poet, *the starry*, and he is said to cover all things. This takes us at once to the Sanscrit Varuna, a name of the firmament, from the root *var*, to cover. The name thus belongs to the same class with ENDYMION, SELENE, TELEPHASSA, &c. Among the children of Ouranos, are HYPERION, TETHYS, and Cronos; but as he was in the habit of banishing his children to TARTARUS, he was unmanned by Cronos, and from the drops of his blood sprang the Gigantes, and APHRODITE, the

child of the sea-foam, i.e. the dawn arising [ANADYOMENE] out of the sea. This myth is repeated in the case of Cronos, who is described as devouring his children after their birth; and in each case it simply means the disappearance of each day, with its sun and its light, its morning and evening, in the abyss of the past. Ouranos, then, is the mighty being whose dwelling is spread over the whole heaven, and who broods over the earth with an unfailing, life-giving love. Hence his offspring is as manifold as that of HERACLES, with whom, as well as with Zeus, his character is almost wholly interchangeable, even in Greek mythology. Heracles (*the sun*) journeys over all lands, and wherever he goes, a rich harvest follows, and noxious things disappear; but the tales of Ouranos, Zeus, and Heracles all become more or less coarse and repulsive, and for the same reason. That which may be said, with beauty as well as with truth, of the heaven (Ouranos), of the sky (Zeus), and of the sun (Helios or Heracles), will not bear translation into the conditions of human life, without degrading the spiritual god into a being who boasts of his unbounded and shameless license. Hence, as the gods become more and more anthropomorphised, the ideas of personal purity and goodness are transferred from Zeus to PHŒBUS, and his sister Athênê. [TRITOGENEIA.]

Uranvitriol. [JOHANNITE.]

Urao. Native sesquicarbonate of soda, found at the bottom of a lake in Macaraibo, in Columbia.

Urceola (Lat. urceolus, dim. of urceus, *a pitcher*). Of this genus of *Apocynaceæ*, the only species, *U. elastica*, a climbing milky-juiced shrub or tree, frequently with a trunk as thick as a man's body, is found in Borneo, Sumatra, and other islands of the Eastern Archipelago. It yields a milky juice, which is collected by making incisions in its bark, or by cutting the trunk into junks, and forms one of the kinds of Caoutchouc called Juitawan; but, owing principally to want of care in its preparation, this Eastern caoutchouc is inferior in quality to that of South America, the milk being simply coagulated by mixing with salt water, instead of being gradually inspissated in layers on a mould. The plant bears many-flowered terminal cymes of small greenish blossoms, which produce double fruits, consisting of two large roundish apricot-coloured rough leathery-skinned parts about the size of oranges, containing numerous kidney-shaped seeds nestling in a copious tawny-coloured pulp, which is much relished both by natives and European residents, and is said to taste like well-bletted medlars.

Urceolate. In Botany, a term applied to that form of corolla which is shaped somewhat like a pitcher with a contracted mouth.

Urdite. [MONAZITE.]

Urea. This substance is the characteristic ingredient of the human urine, and that of the greater number of carnivorous animals. It is a highly azotised substance, represented by the formula $C_2H_4N_2O_2$. It may be obtained by carefully evaporating urine to the consistency of a thin syrup, filtering and adding an equal volume of pure nitric acid; a crystalline precipitate of *nitrate of urea* gradually forms, which, decomposed by carbonate of baryta, yields nitrate of baryta and urea, from which boiling alcohol dissolves out the urea. An *oxalate of urea* may be similarly formed, and decomposed by carbonate of lime into urea, and oxalate of lime. Urea may also be formed artificially in various ways; thus Wöhler obtained it by the careful evaporation of a solution of cyanate of ammonia, a salt which is metameric with urea,

$$\underbrace{NH_4O, C_2NO}_{\text{Cyanate of ammonia}} = \underbrace{C_2H_4N_2O_2}_{\text{Urea}}$$

Urea crystallises in prisms; of a cooling saline taste: it is soluble in water and alcohol; but insoluble in ether and in an excess of nitric acid. It is neither acid nor alkaline. Pure urea is permanent in the air; at 250° it fuses, at a higher temperature it yields ammonia, cyanate of ammonia, and cyanuric acid. When heated in close vessels to between 428° and 464°, it is converted into carbonate of ammonia and water. An aqueous solution of urea remains long without change; but the addition of proteiniferous substances resolves it more rapidly into carbonate of ammonia. In this case 1 atom of urea, and 4 atoms of water, yield 2 atoms of carbonate of ammonia: $C_2H_4N_2O_2 + 4HO = 2(NH_4O, CO_2)$.

The proportion of urea contained in urine is very variable, as will appear by Dr. Golding Bird's analysis. [URINE.] It is increased by exercise, and diminished by rest. Urea has been detected in the blood, and, where the kidneys are extensively diseased, may so accumulate there as to produce a form of narcotic poisoning known under the name of *Uræmia*.

Uredo (Lat. from uro, *I burn*). A genus of microscopical *Fungi*, the presence of which is known by the burnt appearance of the part infested by them. They consist of extremely minute brown protospores, which multiply with great rapidity, and appear to injure plants by absorbing their juices. The species formerly included in *Uredo* are many of them referred to other genera, and the old group *Uredo* rather represents the modern *Uredinei*. Smut or dust-brand, a disease too well known to the farmer, was once thought to be occasioned by attacks of *Uredo*, but the minute fungus which causes that affection is now referred to the genus *Ustilago*. Steeping corn in a solution of blue vitriol is the means resorted to by agriculturists for repelling these attacks. A pound of blue vitriol dissolved in two gallons of water may be thrown on eight bushels of wheat, and the whole being turned over so that the surface of every grain in it is wetted, it will dry of itself in an hour or two, and be fit for sowing. The germs of the destructive fungus with which the dressing comes in contact, are thus destroyed; but from the economy of its growth, botanists consider that

little if any result follows as regards the immunity of the crop.

Ureter (Gr. οὐρητήρ). The membranous tube which conveys the urine from the kidney to the urinary bladder.

Urethra (Gr. οὐρήθρα). The membranous tube or canal by which the urine is voided.

Urginea. A genus of *Liliaceæ*, closely allied to *Scilla*. The species which are natives of the Mediterranean region, and have large bulbs, as in the case of *U. maritima*, the old *Scilla maritima*, are known in medicine as Squills. These bulbs are imported from Malta and elsewhere, some having white scales, while others are of a darker colour, the lighter sort being preferred by druggists. It has been supposed that the Red Squills are the produce of another species, *U. Pancration*, but this seems doubtful. Fresh squills are very acrid, causing irritation, and even vesication, of the skin; the drug is, however, usually imported in the dried state, when its acridity is in great measure decomposed. The bitter taste of squills is due to a substance called *scillitin*. Squills are used in medicine as a diuretic in certain forms of dropsy, and as an expectorant in coughs. [SCILLA.]

Uria (Gr. οὐρία). A genus of web-footed birds, belonging to the short-winged family (*Brachypteres*, Cuv.), and, like the rest of that family, admirable divers. The species of *Uria* are all marine, and generally known by the name of *Guillemots*. They resort in vast numbers to breed among the rocks of the Orkney and Shetland Isles, and are a source of profit to the adventurous inhabitants.

Uric Acid. An acid peculiar to the urine of certain animals; it is always present in human urine, and in the excrements of many birds of prey and of serpents, especially of the *Boa constrictor*, which is voided in white nodules, consisting of little else than urate of ammonia. Uric acid also forms one of the commonest varieties of urinary calculi (hence the term *lithic acid* applied to it), and of the red gravel or sand which is voided in certain morbid states of the urine. Pure uric acid is obtained in the state of a very insoluble white powder by digesting the excrement of the boa, in potash, and dropping the solution into weak hydrochloric acid: the precipitate which falls is to be well washed, and dried at 212°. Its most distinctive chemical character, by which it is at once easily recognised, is, that when moistened with nitric acid and heated it dissolves, and upon evaporation to dryness leaves a red compound, which, upon the addition of a drop or two of a solution of caustic ammonia, becomes of a fine crimson. The composition of uric acid is represented, in reference to its dibasic character, by the formula ($2HO, C_{10}H_2N_4O_4$).

Uric acid requires about 10,000 parts of water for solution, and the greater number of the *urates* are also of very sparing solubility: the most soluble among them is the *urate of lithia*, and lithia water has accordingly been suggested, as preferable to soda or potash water, in cases of gout, gravel, and other disorders connected with excess of uric acid.

Uric acid is remarkable for the number of definite compounds which may be derived from it by various oxidising agents, the products differing with the agent employed. These were first accurately investigated by Liebig and Wöhler, and are important in their physiological and therapeutic bearings, and in reference to the theoretical views which have been founded upon them. Details upon these subjects would be foreign to the purpose of this Dictionary; but some idea of the number, nomenclature, and elementary composition of the derivatives of uric acid may be formed from the following tabular view of them given in Miller's *Chemistry* (2nd edit. vol. ii. p. 732), where also will be found a succinct account of the production and properties of the compounds.

Uric acid . .	$C_{10}H_4N_4O_6$
Urea . . .	$C_2H_4N_2O_2$
Alloxan . .	$C_8H_4N_2O_{10}$
Uroxanic acid .	$C_{10}H_{10}N_4O_{12}$
Dialuric acid . .	$C_8H_4N_2O_8$
Alloxantin . .	$C_8H_5N_2O_{10}$
Alloxanic acid .	$C_8H_4N_2O_{10}$
Mycomelinic acid .	$C_8H_5N_4O_5$
Mesoxalic acid .	$C_6H_2O_{10}$
Leucoturic acid .	$C_6H_3N_2O_6$
Difluan . . .	$C_6H_4N_2O_5$
Parabanic acid .	$C_6H_2N_2O_6$
Oxaluric acid .	$C_6H_4N_2O_8$
Uramil . . .	$C_8H_5N_3O_6$
Murexid . .	$C_{24}H_{10}N_{12}O_{16}$
Allantoin . .	$C_8H_6N_4O_6$
Hidantoic acid .	$C_8H_9N_4O_9$
Allanturic acid .	$C_{10}H_7N_2O_9$
Lantanuric acid .	$C_8H_5N_2O_7$

Urim. A word connected in its signification with the word *thummim*, being the plural of the Hebrew aur, *a light*, *a luminary*; whence it has come to signify fire. *Thummim*, which is the plural of thom or tam, means *fulness* or *perfection*. See Wilkinson's *Ancient Egyptians*, as to the connection of this word with the title of the Egyptian god Thauth or Thoth.

The two words, conjointly, signify *light* and *perfection*; but the Septuagint render it literally δήλωσις καὶ ἀλήθεια, *manifestation and truth*. The urim and thummim are described as the precious stones on the high priest's breastplate, which were supposed to make known the will of God by casting an extraordinary lustre, and thus to *manifest* the success of events to those who consulted them.

Urine (Gr. οὖρον; probably akin to Sansc. vâri, *water*). The fluid secreted by the kidneys, whence it passes by the ureters into the bladder. The variable appearance of the urine announces, even to the casual observer, corresponding fluctuations in its composition; these have long been studied by physicians and medical chemists, as furnishing useful prognostics in disease. The chemical analysis of the urine is attended by many difficulties, arising out of the

number of substances which are found in it, the variations in quantity and quality to which they are liable, and the facility with which they are modified by reagents and by spontaneous changes. The substances found in healthy urine are water; carbonic, phosphoric, hydrochloric, and sulphuric acids; potassa, soda, lime, magnesia, and ammonia. The characteristic organic substances in such urine are urea, and uric acid, together with mucus, and colouring and odorous matters. To these may perhaps be added benzoic, hippuric, lactic, and acetic acids, and traces of hydrofluoric acid, and silica. In certain diseases other products make their appearance, which are not discoverable in healthy urine; such as oxalic acid, nitric acid, sugar in quantity, albumen, cystic oxide, and occasionally some organic compounds, the nature of which has not been satisfactorily ascertained.

When the urine is in a healthy state, there are many circumstances of mind and body which materially influence its appearance and quantity. After very copious draughts of diluting and diuretic liquids, or in hysteria and in some phases of Bright's disease, it is little else than water; at other times it is saturated with its solid contents, and even deposits part of them as it cools. If turbid at the time when it is voided, it may always be considered as in a morbid state. Sometimes it contains foreign matters which have been taken as medicine or food. The peculiar odour imparted to it by asparagus, the colour induced by spinach, rhubarb, &c., and the passage of certain saline substances by the kidneys, are familiar cases of the presence of such foreign matters in the urine. The daily average of urine voided under ordinary circumstances, by healthy individuals, is about 40 ounces; and its specific gravity should not exceed 1030; though in some cases of disease, as in diabetes, it rises to 1050 or more. The usual average is 1020. It always reddens litmus, which indicates free acid. In cases of suppressed perspiration its quantity is usually increased; and when the perspiration is copious, it is diminished. It is one of the great outlets of mere water from the system. It is also the principal channel by which the nitrogen resulting from the decay of the azotised tissues, and from the oxidation of the nitrogenous constituents of food, is carried off.

The following table, showing the average composition of healthy human urine (sp. gr. 1·020), is from Miller's *Chemistry*:—

				In 100 parts of the solid matter.
Water		. . . . . .	956·80	
Solid matters, 43·2	Organic matters, 29·79	Urea . . .	14·24	33·00
		Uric acid . .	0·37	0·86
		Alcoholic extract	12·54	29·03
		Watery extract .	2·51	5·80
		Vesical mucus .	0·16	0·37
	Fixed salts, 13·35	Chloride of sodium	7·22	16·73
		Phosphoric acid	2·12	4·91
		Sulphuric acid	1·70	3·94
		Lime . .	0·22	0·49
		Magnesia . .	0·12	0·28
		Potash . .	1·94	4·47
		Soda . . .	0·06	0·12
			1000·00	100·00

Dr. Golding Bird obtained the following results, in examining 1,000 parts of the urine of a healthy person after ten hours' fasting (*urina sanguinis*), and the urine after dinner in the evening (*urina cibi*):

Analysis of Urine	After fasting	After eating
Specific gravity . .	1·016	1·030
Water	962·72	930·10
Solids	37·28	69·90
Urea	14·30	24·40
Uric acid	0·23	1·33
Fixed salts, chiefly chlorides, sulphates, and phosphates .	5·10	9·90
Organic matter, creatin, creatinine, colouring matter, and volatile salts . . .	17·90	34·27

The above details will give an insight into the composition of healthy urine. In many febrile affections, and in gouty and rheumatic habits, the relative proportion of uric acid is often greatly increased. In Bright's disease, albumen only, traces of which are usually found, sometimes exists in such quantity as to be coagulated by heat and precipitable by nitric acid. Some other substances which occasionally make their appearance are elsewhere mentioned.

Urea abounds in the urine of many carnivorous animals, as in the lion or tiger, and is accompanied by mere traces of uric acid; carnivorous birds excrete little urea, but much uric acid, which abounds also in the excretions of serpents. It appears that in animals which drink freely, the effete nitrogen of the system chiefly passes off in the form of urea; but in birds and reptiles which drink little, and when the urinary excretion is more solid than liquid, it is excreted in uric acid. In graminivorous animals urea and hippuric acid are the leading proximate principles of the urine which contain nitrogen, and they are often accompanied by large quantities of the carbonates of lime and magnesia, while the phosphates are in very small proportion, and pass off chiefly by the bowels.

Urinary Calculi.—When the uric acid of the urine, which we have already stated to be one of its most insoluble constituents, is secreted in any extraordinary proportion, it is passed in a solid state, generally in minute red crystals, or *red sand*; and these not unfrequently agglutinate, so as to form small *calculi* from the size of a pin's head upwards. These, passing with more or less pain from the kidney along the ureter into the bladder, produce what is termed a *fit of gravel*; and if one or more of them remain in the bladder, it may there so increase in size as to become too large to be passed with the urine, giving rise to symptoms of *stone in the*

bladder. The increase of this nucleus will be more or less rapid, according to the state of the urine; but if the inordinate formation of uric acid continues, that substance will frequently be deposited upon it in successive layers, and it will sometimes thus attain a considerable size, and consist almost entirely of uric acid. But if the uric attack in the kidney is transient, the small uric calculus in the bladder usually becomes incrusted with a white deposit, composed of *ammonio-magnesian phosphate*, perhaps with more or less *phosphate of lime*, this mixture forming what has been termed the *fusible calculus*. This gives rise to a second and frequent species of urinary calculus, viz. that in which a uric nucleus is enveloped in the phosphates. The natural tendency of the urine is to deposit these phosphates upon any extraneous matter or nucleus which may chance to be in the bladder; but the rapidity with which it is deposited is very different in different individuals, and accordingly the increase in size of such a calculus is sometimes very slow, and sometimes extremely rapid; and as the violence of the symptoms generally depends (but not always) upon the size of the concretion, they will be subject to great consequent irregularity. It does occasionally happen that calculi are formed in the bladder independent of any morbid state of the urine itself, or of any uric nucleus sent down from the kidneys; but these cases are rare, and appear to depend upon the accumulation of sand and mucus in certain disordered states of the bladder, which is gradually indurated into a nucleus, and which then goes on to increase in the phosphates; so that, on cutting such a calculus through the centre, we do not, as in the majority of cases, observe a uric nucleus, but the whole concretion is white and more or less crystalline, and usually consists of little more than ammonio-magnesian phosphate. The terms *uric* and *phosphatic diathesis* have been applied to those states of the system in which uric acid and the phosphates are abnormally present, and are respectively treated by alkaline and acid remedies. This outline of the formation of calculi includes by far the greater number of cases; but it occasionally happens that not only the nucleus, but the bulk of the stone, is made up of *oxalate of lime*, a substance not found in healthy urine. When these calculi come direct from the kidney, they often are grey and smooth, somewhat resembling a hempseed; or, when more carefully examined, are found to be a congeries of little rounded particles; but when they have increased in the bladder, they are then generally rough and brown on the exterior, whence they have acquired the name of *mulberry calculi*. Another, and more rare substance, which forms gravel and calculi, is the *cystin* or *cystic oxide* ($C_6H_6O_4S_2N$). It is a yellowish substance, translucent, somewhat crystalline, and exhales a peculiar fetid odour. When heated, it is remarkable for the large quantity of sulphur which it contains, amounting to about 25 per cent. Though insoluble in water, it dissolves in dilute acids and alkalies. Another very rare constituent of urinary calculi is *xanthin* or *xanthic oxide* ($C_{10}H_4O_4N_4$). The concretions containing it are pale brown and lamellar. Again, in some very rare cases small concretions of *carbonate of lime* have been voided, most probably originating in the prostate gland. Lastly, minute grains of *silica* are said to have been detected in the urine, and this substance has also been found in calculi; but it is rare, and in small quantity. Another rare form of calculus is also known, called the *uric oxide*. In concluding this sketch of the composition of the urine and urinary calculi, we cannot too strongly insist upon the importance of attending to the early symptoms of the disease, and to its first announcement, which *generally* consists in habitual turbidness and deposits in the urine. All persons are subject to occasional appearances of this kind; but when they are *constant*, they ought to be considered as alarming indications of further mischief. These, in their early stages, are almost always curable, either by diet, medicine, or both; but when once a stone has formed in the kidney or bladder, all hope of its removal, except by an operation (and even that is not admissible in the case of kidney calculi), is vain, nothing having been yet discovered to which the term *solvent* is properly applicable. The removal of the stone from the bladder is effected by operation in two ways: either by an incision into the bladder, and the removal of the stone by a forceps—this constitutes *lithotomy*; or by *lithotrity*, in which certain instruments are introduced by the urethra, so as to grasp the stone, and enable the operator to reduce it to fragments sufficiently small to allow of being voided by the usual passage. Of later years microscopic analysis has been very successfully applied to the detection of morbid conditions of the urine.

Urn (Lat. urna). In Mosses, the hollow vessel in which the spores are lodged.

Urn, Cinerary. A species of vase used to receive and preserve the ashes of the dead. Sir T. Brown's celebrated work, *Hydriotaphia, or Urn Burial*, contains a strange collection of learned fragments and philosophical reflections on this subject. Numerous descriptions of cinerary urns, both Roman and British, discovered at different periods in this country, will be found in the *Archæologia*.

Urocerata (Gr. οὐρά, *a tail*, and κέρας, *a horn*). The name of a tribe of *Terebrantia*, or boring Hymenopterous insects, in which the *terebra* or borer of the females is sometimes very long and prominent, and composed of three filamentary processes, sometimes capillary, and coiled in a spiral form in the interior of the abdomen.

Urodeles (Gr. οὐρά, and δῆλος, *manifest*). The name of that tribe of Caducibranchiate Batrachian reptiles which preserve the tail through all the stages of their existence.

Uropterans (Gr. οὐρά, and πτερόν, *a wing*). The name of a family of Amphipodous Crustaceans, including those in which the tail is

terminated by enlarged appendages in the shape of fins.

Uropygium (Gr. οὐροπύγιον). The base of the tail in mammals and birds.

Uroscopy. The judgment of diseases founded upon an inspection of the urine.

Ursa Major (Lat.). The Great Bear; one of the forty-eight constellations of Ptolemy, in the northern hemisphere, and near the pole. It is often mentioned in the most ancient histories, sacred and profane, under the various denominations of Arctos, Boötes, Helix, Callisto, Megisto, the Waggon, the Plough. It contains seven very conspicuous stars, called *septentriones*; whence *septentrio*, the north. [Rishis, the Seven.]

Ursa Minor (Lat.). The Lesser Bear; also one of the forty-eight constellations of Ptolemy. It was called by the Greeks *Cynosura*; i.e. the *Dog's Tail*. The pole star is in this constellation.

Ursulines. In Ecclesiastical History, an order of nuns, of which the origin is ascribed to Angela da Brescia, about 1537; but which derived its name from St. Ursula (a lady of the family of Benincasa at Naples). The Ursulines were bound to perform charitable offices to the sick, poor, and penitent. They were erected into an order by Gregory XIII. in 1577, at the solicitation of St. Charles Borromeo. They take, in addition to the three ordinary vows, a fourth—to devote themselves to education. (Waddington, *History of the Church*, p. 401.)

Ursus (Lat. *a bear*). A genus of plantigrade Carnivora in the system of Cuvier, restricted to those species which have three large tuberculate molars on each side of both jaws, the anterior lower and the posterior upper one being the largest. They are preceded by a tooth a little more trenchant, representing the carnassial tooth, and by a variable number of small premolars. In accordance with this dentition, the bears are omnivorous or frugivorous. They are heavy, stout-bodied animals, with thick limbs, and a very short tail: the cartilage of the nose is movable, and sometimes very long, as in the labiated bear, commonly called the *ursine sloth*. The bears of the northern regions pass the winter in a state of somnolency in dens or other hiding-places, and it is in these retreats that the female brings forth her young. The species best known are the common brown bear (*Ursus arctos*), the black bear (*Ursus americanus*), the grisly bear (*Ursus ferox*), the polar bear (*Ursus maritimus*), the *Ursus labiatus*, *Ursus thibetanus*, *Ursus malayanus*, and *Ursus syriacus*.

Urtica (Lat. *a nettle*). This genus gives its name to the order *Urticaceæ*, and consists for the most part of erect herbaceous plants, covered with stinging hairs, and commonly called Nettles. The species are numerous, and some of them very widely distributed. The stinging property is met with to a slight extent in our English nettles; but some of the Indian species are particularly powerful in this respect, especially *U. crenulata* and *U. stimulans*. Both these, however, are exceeded by *U. urentissima*, a native of Timor, where it is called by the natives the Devil's-leaf; its effects are so violent as to last for twelve months, and even to produce death. The sting of the Nettle has a bulbous base, which serves as a reservoir for the acrid fluid.

The young tops of the common Nettle (*U. dioica*) are eaten as a vegetable, and may easily be forced for that purpose, when nothing better is to be had; but they are gritty, from the abundance of crystalloid matter contained in the cells of the epidermis. *U. dioica* is, moreover, a very ancient textile plant, its inner bark affording a tough fibre used by the inhabitants in many parts of Europe for making cordage, fishing-lines, coarse cloth, &c. A yellow colouring matter, employed in domestic dyeing, is obtained by boiling the roots with alum; and a decoction of the plant, mixed with salt, coagulates milk.

Some of the species of Nettles possess medicinal properties. Thus, *U. baccifera* is used in the West Indies as an aperient; the root of *U. pilulifera* is astringent and diuretic; nettle-tea, an infusion of the leaves of *U. dioica*, is much used by the peasantry in this country to purify the blood; and the tubers of *U. tuberosa* are eaten, raw, boiled, or roasted, by the natives of India.

Urticaceæ (Urtica, one of the genera). A large natural order of diclinous Exogens, with apetalous flowers, small flat stipules, limpid juice, solitary erect ovules, straight albuminous embryos, and a superior radicle. The stinging properties of the common Nettle are participated in by many others whose acridity is intense, and a tough fibre occurs in many others of the order. They consist of trees, shrubs, or herbs from almost every part of the globe. Taken in an extended sense, the order includes *Artocarpaceæ*, with pendulous ovules and no albumen to the seed; and *Moraceæ*, with pendulous ovules and albuminous seeds; but it is more frequently confined to the *Urticeæ* proper, which have erect ovules and albuminous seeds. The order thus restricted still comprises about forty genera. The species of *Böhmeria* and *Girardinia*, formerly included in *Urtica*, yield valuable fibres. [Böhmeria.]

Urticaria. [Nettle Rash.]

Urvasî. In Hindu Mythology, the story of Urvasî and Purûravas expresses the correlation of the Dawn and the Sun (as in the tales of Daphne, Coronis, Callisto, Augê, and Procris), and the identity of the morning dawn and evening twilight (as in the legends of Iolê, Iocastê, and Œnônê). Even in the Veda, the original meaning of these names has almost faded away; but Professor Max Müller accepts the common Indian explanation which connects the name with *uru*, wide (Gr. εὐρύ), and a root *as*, to pervade, and compares this name *uruasî* with another epithet of the dawn, *urûkî*, the far-going. Thus the name attaches itself to that large class which includes Eurydike, Euryanassa, Eurytos, Eurynome, Eurymedusa.

&c. &c. Again, Vasishtha, the superlative of *vasu*, bright, is, like Phœbus and Lykios [LYCAON], a name for the sun, and Vasishtha is said to owe his birth to Urvasî. In the Hindu story Urvasî falls in love with Purûravas, as Selene is charmed with Endymion; but the name Purûravas corresponds to that of POLYDEUKES, while the hero speaks of himself also as Vasishtha. He is also the son of Idâ, a name sometimes applied to Agni (Ignis), the fire, and reappearing perhaps in that of Idas father of Cleopatra, as well as in the Trojan Ida. The compact between them was that Purûravas was never to appear before Urvasî unclothed; but the GANDHARVAS came and stole two lambs belonging to her, and when Purûravas rose from his couch to rescue them, a flash of lightning revealed his naked form, and, like EURYDIKE from ORPHEUS, Urvasî vanished away. But once again on the banks of a lake full of lotus-flowers, Urvasî showed herself for an instant to her lover, who was seeking her in deep grief. On being addressed by him she replies, 'I am gone like the first of the dawns: I am hard to be caught, like the wind;' but before she leaves him, she bade him come to her on the last night of the year. [YULE.] On that day she told him that the Gandharvas would grant him one wish, and bade him say to them, 'Let me be one of you.' So Purûravas became one of the Gandharvas.

This tale, reproduced, in part, in that of Orpheus, reappears likewise in that of Procris, who is slain unwittingly by the spear of Kephalos, the ray of the unveiled sun. [MYRMIDONS.] It has incidents also in common with the story of Eros and PSYCHE, and all the other tales with which that myth is closely connected. [VENUS.]

Usance (Fr. from Lat. usus, *use*). In Commercial Law. A foreign bill is often drawn at one, two, or more *usances*, meaning thereby certain periods of time which it is the usage of the countries between which the bills are drawn to allow for payment thereof. Thus, the *usance* between London and Paris is one calendar month; a bill drawn here at one *usance*, on January 2, is payable there on February 5, allowing three days of grace.

Use (Lat. usus). In Law, this word, in its original sense, signified the equitable right which one person had to take the rents and profits of land of which the legal ownership was in another. It was very nearly the same as the trust of the present day, and was created in the following manner: The owner of land conveyed it by feoffment to some friend, on the understanding that the feoffee should hold it for the sole use and benefit of the feoffor, or such persons as he might nominate. In this way the seisin or legal property of the land became vested in the feoffee to uses as trustee; while the feoffor, or other person nominated by him, who was called the *cestui que use*, had the substantial use and enjoyment of it. The simplicity of the common law, however, recognised but one person in connection with the soil, viz. its real owner, and repudiated the idea of any use as separated from the seisin; so that if the trustee, abusing the confidence placed in him, refused to let cestui que use take the rents and profits, there was no redress for the grievance. But the Court of Chancery, as a court of equity, considered the agreement entered into by the trustee as binding on his conscience; and after calling on him by writ of subpœna to appear and make a disclosure on oath of the particulars of his trust, compelled him to perform it.

The system of uses was transplanted from the civil law, and introduced into this country about the time of Edward III. by the ecclesiastics, who procured conveyances to be made, not directly to themselves, but to lay persons as trustees for them, in order to evade the Statutes of Mortmain. Once known, it was generally adopted; and though crushed in its infancy, so far as regarded religious houses, it continued to flourish without disturbance in other respects, and was found admirably adapted to the wants and convenience of the people at large in softening the rigours of feudal tenure, and facilitating the alienation and settlement of property.

The laws and policy of feudal tenure required the vassal to render certain fruits and services to his lord; and if these were not duly rendered, or any act were done in derogation of the lord's title, the estate was forfeited. The tenancy of the freehold could not be interrupted or suspended for an instant; and to every transfer of it actual and public delivery of possession was absolutely indispensable; so that the lord might always have some person to perform the services due to him, and always know with certainty who that person was. The lord was entitled to sell his ward in marriage, to take the profits of the land during the wardship, and on the descent or alienation of the land heavy fines were payable to him. The tenant had no power of directing the destination of the land by will; such a mode of disposition would at once have been wanting in notoriety, and have deprived the lord of his fruits upon a descent.

When, however, the equitable interest in land, as distinguished from the legal property in it, became recognised and enforced in the Court of Chancery, the principal hardships of tenure were easily avoided. A conveyed land to B to A's own use; the terms upon which B took the land were said, in equity, to affect his conscience, and to impose upon him a moral obligation to fulfil them honestly. But it was in equity only that A had any claim: there he might call upon B to allow him to take the profits of the land, and to make such conveyances of it as he might from time to time direct. At law A had no control over or connection with the land any longer remaining to him. His use, therefore, altogether evaded the grasp of tenure, which rested entirely upon the common law. It was held of no one; it was the

creature of his own declaration, operating upon the conscience of the person in whom he confided. It might be transferred at any time without any public solemnities by a secret declaration. At law A could not carve out for himself a portion of the whole fee, and limit the residue of it to others, without first of all going through all the formalities of a conveyance to B, and then taking back a reconveyance, with the same formalities, of that portion of the fee which he might wish to retain to himself. Husband and wife being one person in law, he could not carve out a portion for her without conveying to B, in order that B might afterwards convey to her. He could not convey the fee, or any portion of it, to B, so that it should, on the happening of any named event, or the expiration of any named period, shift either wholly or in part from him to any other person. He could not even convey to B at all without giving him immediate possession: a conveyance to him in futuro, as from Christmas next, would have been altogether void. He might, however, resorting to equity, and making a declaration of the uses to which he wished his property to be applied, effect all these and innumerable other arrangements by a single stroke of the pen, or a mere breath. The use, emancipated from the common law, had such a suppleness and pliability as almost to accommodate itself to his very whims. He might dispose of it by will, or it would descend to his heirs in the course of the common law; but no fine was payable upon its descent. It was not liable either to dower or to curtesy; it was not extendible for debts, nor forfeited for treason. Lord Bacon accordingly complains, that it 'deceived many of their just and reasonable rights. A man that had cause to sue for land knew not against whom to bring his action, or who was the owner of it. The wife was defrauded of her thirds; the husband of his curtesy; the lord of his wardship, relief, heriot, and escheat; the creditor of his extent for debt; and the poor tenant of his lease.

To remedy these and other inconveniences, the statute 27 Henry VIII. c. 10 was passed, usually called the Statute of Uses; which enacts, that when any person shall be seised of lands to the use, confidence, or trust of any person, he shall thenceforth be seised and possessed of the land of and in the like estate as he had in the use, trust, or confidence. The statute thus executed the use, as it is called, by transferring it into possession, and doing away with the distinction between the beneficial interest and legal property in land. Whoever had the use had now also the legal estate. Thus the use was not abolished, according to the probable intention of the legislature, but merely annexed to and incorporated with the legal estate; to which, therefore, it now superadded all the convenient ductility of its own nature. It had no longer a merely precarious existence in equity, but a firm locus standi in courts of law. It was shorn, indeed, of many of its old privileges, such as exemption from dower, curtesy, and forfeiture; but for this loss there was soon contrived a remedy. The judges, in their narrow construction of the statute, decided that its provisions did not extend to *a use limited upon a use*, as their phrase was. Accordingly, on a feoffment to A and his heirs, to the use of B and his heirs, to the use of (or in trust for) C and his heirs, they held that the statute clothed the first use with the legal ownership, and that the second was a nullity. But as it was quite clear that C, and not B, was the person intended to enjoy the estate, this verbal pedantry of the common law judges drove C into the Court of Chancery for relief, where he was immediately received as the substantial cestui que use; and the use which the statute had been in law held not to execute was considered a valid *trust* in equity. Thus by limiting two uses successively instead of one only before the statute—by making, in fact, the conveyance only three words longer than had been customary, the equitable interest and the legal estate were again disunited, and the use under its new name of *trust* was as popular and available as ever. In this manner the destructive qualities of the statute are virtually repealed, while its creative qualities are to this day in full operation; and the legislature, instead of paralysing the use, has only given new form and flexibility to the legal estate. [TRUST.]

Useful Knowledge, Society for the Diffusion of. [SOCIETY.]

Usher (Fr. huissier). An officer who has the care of the door of a court or hall, &c. In the court of England, he is an officer of considerable rank, whose business it is to introduce foreign ambassadors or other high strangers to the sovereign.

Usnin or **Usnic Acid.** A substance extracted from different lichens of the genus *Usnea.* It forms yellow crystals, which with great difficulty are fused like a resin. It has slightly acid characters, and forms crystallisable compounds with the alkalies: hence it has been called *usnic acid.* Its ultimate composition is represented by the formula $C_{38}\,H_{18}\,O_{14}$.

Usquebaugh. A strong compound cordial, made in greatest perfection at Drogheda in Ireland. Brandy or other spirits, raisins, cinnamon, cloves, and various other spices are its ingredients. The first part of the word, which has been corrupted into *whisky*, is akin to the Latin aqua, the Greek ACHELOUS, ACHERON, and the many collateral forms exhibited in the names of rivers, as Esk, Usk, Exe, Ax, Axius, Oxus, Ouse, Isis, &c.

Ustrinum (Lat. from uro, *I burn*). In Roman Antiquities, a public burning-place, enclosed by walls, in which bodies, mostly of the poorer sort of people, were consumed. In the *Archæologia* (vol. xxvi.) will be found a detailed account of the site of an ustrinum discovered in Cambridgeshire.

Ustulation (Lat. ustulo, *to burn*). A term of old Pharmacy, implying the gradual desiccation and torrefaction of substances.

Usucaption (Lat. usucapio). In Civil Law, the acquisition of property in anything by possession and enjoyment for a certain term of years; commonly considered as synonymous with *prescription*, although some have restrained the use of the former term to movables only.

Usufruct (Lat. ususfructus). In the Civil Law, this term is defined to be the right of enjoying indefinitely something belonging to another without diminishing its substance. *Usufruct* differs from *use*; because he who has the use of a thing can only enjoy it personally, whereas the right of him who has the usufruct is alienable, and may be granted, sold, or hired to another. Usufruct may be constituted in four ways: by contract, by will, by judgment of a court (as where the judge, in effecting a division of common property, may, under certain circumstances, instead of dividing the inheritance, allot the usufruct to one, and the thing to another), and by operation of law. Usufruct is, properly speaking, confined to things real, and to incorporeal rights (whether they would be termed *real* or *personal*, according to the division of our law), such as debts; but a sort of usufruct (quasi usufruct) may exist in things liable to be consumed by use. The division between the fruit (which belongs to the usufructuary) and the thing itself (which belongs to the proprietor) affords room for a great variety of legal distinctions. Usufruct may be extinguished in several ways: by the death, natural or civil, of the usufructuary; by loss; by prescription, the right being extinguished if disused for a certain period; by forfeiture, where the usufructuary abuses his right; by expiration of time, if the usufruct have been granted for a term; and by the union of the usufruct with the property in the same hands.

Usury (Lat. usura, *the use of a thing*: hence profit arising from this use). The taking of interest for money. The Jews were forbidden by the law of Moses to exact interest from one another. By the old Roman law of the twelve tables, the rate of interest allowed as legitimate was the usura centesima, which was strictly 1 per cent. a month; and has been supposed by some to have amounted to 12, by others to 10 per cent. in the year. Interest was also computed in the following manner: Usura unciaria, being the lowest term, 1 per cent., or one-twelfth of the usura centesima; usura semis, or semis, half the centesima (6 per cent.); bes, quadrans, quincunx, &c., two third parts, a quarter, a fifth of the centesima (8, 3, 2 per cent.). The Roman laws against excessive usury were frequently renewed, and constantly evaded; but the same principle, additionally sanctioned by mistaken religious opinions, pervaded the laws of all countries in which the civil jurisprudence prevailed. The amount of legal interest has been fixed by various statutes in England. In the reign of Henry VIII. 10 per cent. was allowed; by 21 James I., 8 per cent.; by 12 Ch. II., 6 per cent.; by 12 Anne, 5 per cent.

Subsequently to the passing of the latter Act, the usury laws were relaxed by several statutes, and they were ultimately repealed in 1854. Any rate of interest, therefore, however high, may now be legally stipulated for, but 5 per cent. remains the legal interest recoverable on all contracts, unless otherwise specified.

One of the earliest and most consistent among the fallacies which have ever occupied men's minds, and not only the minds of the general public, but those of the most subtle thinkers, is that which has contended that the interest of money was unlawful, immoral, or inexpedient. It is clearly the duty of society to protect creditors against debtors, but from time to time it has been considered just to relieve debtors against creditors, when the obligations of the former have arisen from usury taken for the loan of money. Thus the legislation of Solon relieved the Athenian mortgagors [SEISACHTHEIA]; and during many years of the history of republican Rome, the regulation of loans, the limitation of the rate of interest, and the relief of insolvent debtors, formed a perpetual topic of agitation, and finally of legislation. In this country, and in most European countries, the administration has busied itself from time to time in fixing rates of interest, and in denouncing or forbidding usurious bargains. It is hardly necessary to say that this legislation has been vain, and that while the most stringent laws were in force, high rates of interest on loans were common, the law being incompetent to provide such precautions as should obviate all evasions of the statute. (For further remarks on the distinction between ancient and modern debts generally, see Grote, *Hist. of Greece*, part ii. ch. xi.)

The usury laws now repealed were attacked with great force and cogency by Bentham. [INTEREST.]

Ut. In Music, the French name of the first of the musical syllables referring to the note which we call C. The Italians, for the sake of softening the sound, use the syllable *do* instead of *ut* in the modern solfeggi.

Uterine (Lat. uterinus). In Anatomy, that which appertains to the womb, as the uterine arteries, veins, nerves, and the uterine portions of the placenta or cotyledons.

UTERINE. In the Civil Law, a uterine brother or sister is one issued from the same mother.

Uterus (Lat.). The womb, or the muscular and vascular part of the efferent canal or tract in the female viviparous or ovo-viviparous animal, in which the fœtus is developed. In the human subject and in quadrumana it is single; in many quadrupeds it is bifid; in some, it is completely divided into two symmetrical uteri.

Uti Possidetis (Lat. *as you hold*). In Politics, a treaty, which leaves belligerent parties mutually in possession of what they have acquired by their arms during the war, is said

to be based on the principle of *uti possidetis* (as you possess).

Utilitarians (Lat. utilitas, *usefulness*). A name much in use a few years ago to designate a particular sect of modern politicians; those viz. who profess to try the excellence of modes of government and usages simply by their utility. The celebrated Jeremy Bentham, regarded as the founder of this sect, introduced into the critical department of politics a closer logic than had been commonly applied to it; and aimed at applying his famous principle, 'the greatest happiness of the greatest number,' as an immediate test by which to affirm or deny the value of institutions. It is evident that all political sects, both of writers and statesmen, profess ultimately the same object. The real characteristic of the Utilitarians consisted in the peculiar sense in which they understood it, the term *utility* being restricted to that which is useful for the material and economical well-being of the multitude. Their tenets were attacked by Lord Macaulay in two celebrated articles in the *Edin. Review* (vols. xlix. and l.). Mill's *Essay on Government*, and Austin *On Jurisprudence*, may be referred to as containing the most intelligible summaries of them.

Utopia. A term coined by Sir T. More (from Gr. οὐ, neg. and τόπος, *a place*), and applied in his celebrated work called *Utopia* to an imaginary island, which he describes as having been discovered by a companion of Amerigo Vespucci, and as enjoying the utmost perfection in laws, politics, &c., in contradistinction to the defects of governments then existing. (Hallam, *Literary History*, part i. ch. iv. 34.) The work was first printed in 1516, but Froben's edition, of 1518, is more correct. The word *Utopia* has now passed into all the languages of Europe, to signify a state of ideal perfection; and *Utopian* is used synonymously with *fanciful* or *chimerical*.

Utr. An Eastern name for the essential oil or attar of roses.

Utraquists (Lat. uterque, *both*). In Ecclesiastical History, a name given to the followers of John Huss as insisting on Communion in both kinds. This stipulation formed one of the four articles drawn up at Prague, A.D. 1422. (Milman, *Latin Christianity*, bk. xiii. ch. xi.)

Utriculus (Lat. dim. of uter, *a leathern bag*). In Anatomy, this term is applied to the upper and larger of the two divisions of the vestibular portion of the membranous labyrinth of the internal organ of hearing.

Utriculus. A term in Botany applied to a one-celled, one or few seeded, superior membranous fruit, frequently dehiscing by a transverse suture, as in *Chenopodium*. It is also used to indicate a fruit with a thin skin and a single seed. Sometimes this word is employed to express a separate cell of the cellular tissue of a plant, which is usually a little vegetable bladder.

Uva Ursi (Lat.). The *Arctostaphylos uva ursi*, or *Bear's berry*, a small shrub, the leaves of which have a highly astringent and sweetish taste. Their decoction or infusion is occasionally used in medicine, especially in certain disorders of the kidney and bladder.

Uvaria (Lat. uva, *a grape*). A genus of *Anonaceæ*, containing numerous species, all climbing plants, covered with star-shaped hairs, and occurring in the tropical and subtropical districts of the Old World, from Western Africa to the Philippine Islands. The roots of *U. Narum* are fragrant and aromatic, and are used medicinally in India, in fevers and liver complaints. Bruised in salt water, they are employed as an application in certain skin diseases; by distillation they yield a fragrant greenish oil. The bark of *U. tripetaloidea* yields by incision a fragrant gum. *U. triloba* is said to contain a powerful acid; its leaves are used as an application to boils and abscesses, while its seeds are emetic. *U. febrifuga* is so called from the febrifugal properties ascribed to the flowers by the Indians on the Orinoco.

Uvic Acid (Lat. uva). A synonym of the *racemic* or *paratartaric acid*, an acid isomeric with the tartaric, but differing from it in certain respects, more especially in its relations to polarised light. [Tartaric Acid.]

Uvula (Lat. uva). A small fleshy protuberance attached to the soft palate, and hanging over the base of the tongue. It consists of the common integuments of the mouth, and a small vermicular muscle (*palato-staphilinus*) by the contraction of which the uvula is elevated. In some cases of enlarged or relaxed uvula, which will not yield to local or other remedies, it becomes necessary to amputate a part of it, in consequence of the tickling cough and retching which it induces.

Uwarowite. A lime-chrome Garnet of an emerald-green colour, found at Kyschtimsk and Bissersk in the Ural; and named after Uwarow, president of the Imperial Academy of St. Petersburg.

V

V. The twenty-second letter of the English alphabet. It is vocal, the corresponding aspirate being F. In many Greek words it is represented by the Digamma. As a Roman numeral, V stands for 5. With a dash over it, $\bar{V}$, in old books, it denotes 5,000.

Vacation. In Legal language, the period during which juridical proceedings are intermitted: in England, the periods between the four terms of the year [Terms] are so called. But the *long vacation*, from August 10 to October 24, at Common Law, and October 28

in Chancery, implies a more general cessation of all but urgent business.

Vaccination. [Cow-pox.]

Vacciniaceæ (Vaccinium, one of the genera). A natural order of epigynous Exogens closely allied to *Ericaceæ* in their stamens being free from the corolla, and in the peculiar form of their anthers as well as in most other characters, but separated by almost all botanists on account of their constantly inferior ovary and fruit. They consist of much-branched shrubs or small trees, often evergreen. The species are numerous in the temperate and colder parts of the world, especially in swampy or subalpine countries, as well as in high mountain chains within the tropics. They were formerly combined with the Ericaceous order, from which, however, they differ, not only in their inferior ovary, but also in their succulent fruit. The berries of many are eaten, under the names of Cranberry, Bilberry, Whortleberry, &c.

Vaccinic Acid. A peculiar volatile acid which occasionally replaces the butyric and caproic acid in butter.

Vaccinium (Lat.). A genus of heath-like shrubs, dispersed through a very wide area in both the Old and New World, and generally in mountainous districts or wet heathy places. Three species are natives of Great Britain, the most frequent being *V. Myrtillus*, the Whortleberry or Bilberry, an erect little shrub, common on our heathy wastes, whose fruit is much esteemed for preserves, syrups, &c.

Vachellia. A name under which it was proposed to separate *Acacia Farnesiana* from the other species of that genus. It is now usually retained as a section of that extensive family, and includes the gum arabic tree (*Acacia arabica*) and other gum-producing species. The flowers of *Acacia Farnesiana* afford the Cassie flowers of the perfumers, who extract their fine violet-like odour by macerating them in purified fat or the finest olive oil, and use it in the preparation of various bouquets, or for mixing with violet perfumes to increase their strength. Originally it appears to have been confined to the tropics of the western hemisphere, but it is now common in nearly all tropical countries, and also in many parts of the south of Europe, where it was introduced early in the seventeenth century. Large quantities of gum, resembling inferior gum arabic, exude from its trunk and branches.

Vacuna (Lat.). In Mythology, a Sabine deity, who is thought by some to be the same as the Latin *Victoria*. (Ov. *Fast.* vi. 307.)

Vacuum (Lat. vacuus, *empty*). In Physics, this term denotes a portion of space void of matter. The possibility of the existence of a perfect vacuum has been a favourite subject of dispute with the schoolmen and metaphysicians. [Space, Number, and Time; Space, Physical.] Its existence was maintained by the Pythagoreans, Epicureans, and Atomists; and denied by the Peripatetics, who ascribed the rise of water in a sucking-pump, and some other phenomena of the same kind produced by atmospheric pressure, to nature's abhorrence of a vacuum. Descartes made the essence of matter to consist in extension, and therefore denied the possibility of a vacuum; for if extension be the essence of matter, wherever extension is there matter must be. Those, again, who suppose all material bodies to be formed of the agglomeration of elementary particles, are compelled, by the phenomena of motion, to admit at least the existence of that which the schoolmen called *vacuum interspersum*, or of intervals devoid of all matter among the interstices or pores of bodies; for if there were no interstices, all space would be full of matter, in which case no body could be moved out of its place, inasmuch as there would be no unoccupied place into which it could move. For the arguments on this subject, see Newton's *Optics*.

Until recently the most perfect vacuum that could be produced was the *Torricellian vacuum*, or the space above the mercury in the barometric tube. But in this sense vacuum merely signifies the exclusion of atmospheric air; for this space in the barometer may be filled with the vapour of mercury, or with some other medium infinitely more rare than air, and inappreciable to our senses. It is obvious, from the nature of the pneumatic machine, that the vacuum produced by an air-pump, or the *Boylean vacuum*, as it has been called, can never be perfect, as some air must always remain in the receiver, however long the exhausting process may be continued, but if the receiver be first filled with pure carbonic acid, a stick of caustic potash introduced, and then the receiver be exhausted as perfectly as possible, the stick of potash will gradually absorb the small residuum of carbonic acid, and a vacuum far exceeding the Torricellian will be produced after the lapse of a few hours. This is by far the most perfect vacuum that has yet been obtained; but the electric discharge sent through it still proclaims it to be imperfect.

The question of the abstract existence of a vacuum is not worth discussing; but there is another question of great interest with reference to physical astronomy connected with the subject—viz. whether the spaces in which the planets move are so far void of matter as to offer no resistance to their motions, or are occupied by a medium of sufficient density to impede their motions in the long run in a sensible degree. Recent observations appear to give some countenance to the supposition that this is actually the case. It has been observed that after the most careful allowance has been made for the attractions of the planets, and all other known causes of disturbance, on Encke's comet, the successive returns of that body to its perihelion are accomplished in periods which are constantly diminishing. [Comet.] Now, this is precisely the effect that would be produced if the body moved in a medium which offered

a small resistance to its motion; and as this is the only obvious mode of explaining the phenomenon, it has been generally adopted. Nevertheless, it is extremely difficult to reconcile the supposition of an existing medium with the astronomical fact, that, during the last 2,000 years of observation, it has produced on the motions of the large planets no effect which can be appreciated by the most delicate instruments. This fact, however, though it proves the extreme feebleness of the resistance, does not furnish an absolute proof that such a medium may not exist, and that its effects may not ultimately become sensible even on the densest planets. If it does exist, the consequence seems inevitable that all the planets and satellites, as well as the comets, must be ultimately precipitated into the sun.

Another argument against the existence of a vacuum is furnished by the undulatory theory of light. If this hypothesis be true, and it is rendered probable by numerous phenomena, a medium of great elasticity must pervade all the parts of space through which light penetrates. There could in this case be no vacuum; unless, indeed, the term be understood to denote merely the absence of ponderable matter. [LIGHT.]

Vade Mecum (Lat. *go with me*). A phrase commonly used to denote a portable book or manual, which anyone carries on his person.

Vade in Pace (Lat. *go in peace*). In monastic communities offences were sometimes punished by the dreadful infliction of starving the culprit to death in prison; and bones have occasionally been found among the ruins of convents of victims who appear to have perished in this manner. The punishment acquired this name from the words in which the sentence was pronounced. The use which Walter Scott has made of this custom in his poem of *Marmion* is well known. By Fleury (*Hist. Eccles.* vol. xx. p. 102) the *vade in pace* is described as perpetual solitary imprisonment.

Vagantes (Lat. part. of vagor, *I wander*). The name of a tribe of spiders (*Araneidæ*), comprehending those which watch their prey concealed in a web, but also frequently run with agility, and chase and seize their victims.

Vagina (Lat. *a sheath*). This term is applied by botanists to the leafstalk of those plants in which this part becomes thin and rolls round the stem, to which it then forms a sheath, as in grasses.

Vaginates (Lat. vagina). Sheathed Polypes. The name of an order of Polypes, comprehending those which are constantly surrounded by and attached to a calcareous or horny polypary.

Vagrancy (Lat. vagor, *I wander*). In English Law, a very miscellaneous class of offences against public police and order is comprehended under this title. Vagrants, under the present Act of Parliament in force on the subject (5 Geo. IV. c. 83, amended by 1 & 2 Vict. c. 38), are of three descriptions: 1. *Idle and disorderly persons*: including persons neglecting to maintain their families; paupers returning without certificate to parishes whence they have been legally removed; beggars, common prostitutes, pedlars without license, &c.; all of whom may be summarily convicted and committed to gaol for a month by any single justice, subject to an appeal to the sessions. 2. *Rogues and vagabonds*: including persons guilty of the former offences, who have been once already convicted of being idle and disorderly; fortune-tellers and other impostors; persons guilty of indecent exhibitions, procurers of charitable contributions under false pretences, playing at games of chance in public places, having in their possession housebreakers' implements, or offensive weapons, with intent to use them; reputed thieves frequenting public places to commit felony, and others; all of whom may be committed for three months. 3. *Incorrigible rogues*: viz. persons guilty of the last class of offences having been already convicted; persons breaking out of legal confinement, &c., who may be committed to the next sessions, and there sentenced to a year's imprisonment. Under these Acts, justices possess very extensive powers, such as to issue warrants to bring before them persons suspected of vagrancy, to search lodging houses reasonably suspected of harbouring vagrants, &c.

Vahea. A genus of *Apocynaceæ* yielding Caoutchouc. Much of the Indian-rubber consumed by our manufacturers is obtained from *Siphonia brasiliensis* and *Ficus elastica*; but the same substance is found in the milky juice of numerous plants belonging to the natural order *Apocynaceæ*: e. g. *Urceola*, *Cameraria*, *Collophora*, *Willughbeia*, and the present genus, although, with the exception of *Urceola*, it is not collected from them for commercial purposes. Two species of *Vahea*, viz. *V. madagascariensis*, the Voua-Héré of the natives, and *V. gummifera*—both large climbing shrubs or trees of Madagascar, are known to afford an abundance of caoutchouc, which will probably at no distant date form an article of export from that magnificent island.

Vair (perhaps from the Lat. varius, *diverse*). In Heraldry, one of the furs employed in blazonry. It is supposed to represent the skin of a small squirrel. It is always white and blue, unless otherwise specified in the blazon: as vair of *or* and azure, vair of ermine and gules, &c. *Vairy* is the pattern of vair with more than two colours. The *glass slipper* of Cinderella in the popular legend was probably a slipper of *vair*, altered by the storyteller into *verre*.

Vaisya. [CASTE.]

Valencianite. A variety of Adularia, found at the Valenciana Mine in Mexico.

Valentia. [ROMULUS.]

Valentine. February 14 is the day sacred to St. Valentine, a presbyter, who, according to the legend, was beheaded at Rome under Clau-

dius. Mr. Brand (*Popular Antiquities*, vol. i. p. 47) says that he cannot find in the life of the saint any circumstances likely to have given origin to the peculiar ceremonies of the day. It appears to have been a very old notion, however (for it is alluded to by Chaucer, as well as by Shakspeare in the *Two Gentlemen of Verona*), that on this day birds begin to couple. And the custom of 'choosing Valentines' is of great antiquity in this country. Lydgate mentions it (1746); Grose explains Valentine to mean 'the first woman seen by a man, or man by a woman,' on that day; but it does not appear where he picked up this explanation. There is also a curious French Valentine, composed by the poet Gower, in Wharton's *History of English Poetry* (Additions to vol. ii. p. 31).

It appears that the Reformers attacked this as well as other legendary customs of their time; and that the Romanists themselves invented devices for turning the day to profitable use. St. Francis de Sales introduced the practice of drawing lots for patron saints on it, by way of substitute. According to others, this latter practice was of much older date, and substituted for a pagan custom by which boys and girls drew each other's names on the 15th February (day of Februata Juno).

Valentinians. In Ecclesiastical History, a sect of the second century; so called from Valentinus, their founder. They were a branch of the GNOSTICS.

Valentinite. Native antimonic oxide, composed (when pure) of 84·3 per cent. antimony and 15·7 oxygen. It is found in tabular crystals at Przibram in Bohemia, and elsewhere, associated with other ores of antimony, of the decomposition of which it is a result. Named in honour of Basilius Valentinus.

Valerian. [VALERIANA.]

Valeriana. A genus of herbaceous plants, widely distributed over tropical and extra-tropical America, India, and Central Europe, and more sparingly in North America; found for the most part in mountainous districts. Many of the species are employed in medicine, on account of their peculiar stimulant and antispasmodic properties. The species now most used is *V. officinalis*, the Officinal Valerian, common in marshy and wet places in this country and Central Europe; the roots have a warm, aromatic, slightly bitter taste, and, when dry, a peculiar fetid odour, which seems to be especially agreeable to cats, who become, as it were, intoxicated with it. It is stated also that rat-catchers avail themselves of this root as a means of attracting their prey. This odour seems to be due to the presence of a peculiar acid called *valerianic acid*. What is known to chemists as *volatile oil of Valerian* seems not to exist naturally in the plant, but to be developed by the agency of water. Valerian is used in medicine as a powerful stimulant to the nervous system in hysteria, and even in epilepsy. On the Continent it has likewise been used as a febrifuge. *V. celtica* is supposed to be the Saliunca of ancient writers. Its perfume is so highly prized by Eastern nations, for the purpose of aromatising their baths, that the roots, collected by the Styrian peasants with no slight difficulty and labour, are exported by way of Trieste to Turkey and Egypt, whence they are distributed to India and Ethiopia.

Valerianaceæ (Valeriana, one of the genera). A natural order of epigynous Exogens consisting of annual or perennial herbs, inhabiting temperate climates. They are distinguished from the Dipsaceous order by their flowers not being in heads, by the want of albumen, and the absence of an involucel. The roots of *Valeriana officinalis* are aromatic and antispasmodic; and the young leaves of the species of *Valerianella* are eaten as salad, under the French name of *mâche*, or the English one of Lamb's Lettuce and Corn Salad.

Valerianic or Valeric Acid. This acid constitutes the leading ingredient of the volatile oil obtained by distilling valerian root with water. It may also be obtained from the root of *Angelica*; and it is contained in the bark of the *Viburnum Opulus*. Lastly, valerianic acid is artificially formed by the action of a mixture of quicklime and caustic potassa on the oil of potato spirit, the *fusel oil* of the Germans, the *hydrated oxide of amyl* of chemists, or by distilling fusel oil with a mixture of dilute sulphuric acid and bichromate of potash. The formula of this acid is $C_{10}H_9O_3 + HO$. It is an oily colourless liquid, boiling at 347° Fahr. (175° C.), smelling intensely of valerian; it has a sour, pungent, and nauseous taste, leaving a sense of sweetness and a white spot upon the tongue. Some of its combinations with bases have been used medicinally as nervine tonics.

Valesians. An ancient sect mentioned by Epiphanius, and supposed to have become known about A.D. 240; they are said to have adopted the practice of eunuchism.

Valet, Varlet. A term used originally to denote the sons of knights, and afterwards those of the nobility before they had attained the age of chivalry. The name is sometimes written *vasletus*, and seems to be derived from the same root with vassal; probably the Celtic gwâs. [VASSAL.] *Valet* in French, and *varlet* in English, degenerated in later times into the signification of *servant*.

Valhalla or **Walhalla.** In the Scandinavian Mythology, the place in which ODIN and the Æsirs dwell with the beautiful VALKYRIES and the heroes slain in battle. [THOR; TYR.]

Valkyries. In Scandinavian Mythology, maidens who dwell with the Æsir in Walhalla, and whose office it is, as corse-choosers, to conduct to the home of the gods the souls of heroes slain in battle. They were also called *Oska-mær*, or wish-maidens. [WISH.] Allowance being made for the influence of climate in the character of mythical systems, the valkyries

exhibit a close resemblance to the houris who are the reward of the faithful in the sensual paradise of Mohammed.

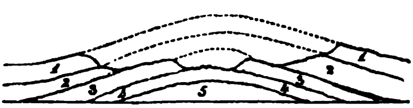
Valley (Lat. vallis). In Architecture, the internal angle formed by two inclined sides of a roof. It is supported by a rafter called the *valley rafter*, or *valley piece*; on which lies a board for the reception of the lead gutter, called the *valley board*.

Valley of Denudation. A valley formed by the direct action of water scooping out a passage for itself by its mere mechanical force. Such valleys are formed very rapidly in districts where the rocks are soft, as the water first eats away a passage for itself to a certain depth, and then widens this passage by undermining the banks which it has itself formed. When a wide gap has been formed, the water in different seasons deepens some particular channels, and afterwards these channels are widened, and so on until the result becomes very large. Sir C. Lyell relates as an example of the force of running water in denudation, that the river Simeto, the largest of the Sicilian streams, having had its course obstructed by lava, which was poured out in 1603, has since then eaten away through the lava a passage from 50 to 100 feet wide, and from 40 to 50 feet deep.

The action of marine currents at the bottom of the sea is also very great, and probably scoops out large hollows, which will be laid bare and become valleys at some future time, when the sea bottom shall have become dry ground.

Valleys of denudation are common in most countries, as the river channel of most streams is far larger than the space now occupied by the water.

Valley of Elevation. A valley formed in consequence of the lifting up of a considerable tract of country by an axis of elevation, followed, or accompanied by, a removal of the broken fragments on the axis by the action of water. The accompanying diagram will illustrate the phenomenon by a sectional view.



The beds 1 to 5 have been originally horizontal, but have undergone elevation, breaking the upper series. The elevation being supposed to be gradual, the removal of the broken rock of the various deposits would proceed continuously, leaving a succession of low ridges, in the direction of the axis; but instead of a hill in the central line of the axis, there would be a comparative depression or valley. It will be evident that a true valley is thus formed, although the lowest part of the valley is above the level occupied by the highest bed of the series before elevation commenced.

An important geological result follows this construction of the valley, as the beds 2 and 4 in the diagram will be seen to have the same position with respect to the sea level at the place where they crop out, although 4 is, geologically, much below.

It is possible that the lowest bed may, by the greater denudation of the upper ones, be nearly level with them.

Valleys (Lat. vallis). The phenomena of valleys possess great interest both to the physical geographer and the geologist. They are generally depressions in mountain districts, but the name is also applied to the channel by which any stream or river is conveyed along a plain country to the sea. In the former case they are not unfrequently characterised by some peculiar features, especially in the upper regions of high mountains, where the ice which partially occupies them often works its way into the plains below before melting. [GLACIERS.] In the latter case, the title *valley* belongs to large and wide plains, including not merely the present water current, but all that tract of alluvial matter which has in former times been deposited by the stream.

Besides the valleys traversed by rivers, and therefore lower at one end than at the other, there are many into which no water runs, while some, which are quite enclosed, allow no water that may enter them to escape, except by evaporation. In such valleys there are often lakes, some being SALT LAKES, the remains of sea water once contained in them.

Valleys have been formed in various ways. Some, called *valleys of erosion*, are due wholly to the rapid production of a channel by water rushing for a time as a torrent through a soft material. [VALLEYS OF DENUDATION; VALLEYS OF ELEVATION.]

Some mountain chains are remarkable for peculiar systems of valleys, and in some the position of the valleys is extremely elevated. This is especially the case in the knots of the ANDES.

A view has been put forth by some German geologists, and accepted by some of their English brethren, to the effect that all lake valleys have been scooped out by ice. This view may perhaps in many cases be extended to the larger river valleys.

There can be little doubt that the principal systems of valleys in mountain districts are due to the causes that have lifted the mountain chain itself, and that if the great valleys away from mountains are due partly to the rivers that still traverse them, they are more directly the result of the circumstances under which they have been elevated from the sea, and acted on during elevation.

Vallisneria (after Antonio Vallisneri, an Italian botanist). A genus of *Hydrocharidaceæ*, remarkable on account of the very curious manner in which the process of fertilisation is effected.

The best-known species, *V. spiralis*, found wild in many parts of Southern Europe, is a perennial herb, bearing a tuft of thin narrow green grass-like leaves. The two sexes are borne on separate plants. The male flowers

are extremely minute and sessile, but when mature they become detached, and rise to the surface of the water. The female flowers, on the other hand, are borne singly at the end of a very long slender spirally-twisted stalk, which uncoils more or less according to the depth of the water, so as to allow the flower to float upon the surface, where it expands and is fertilised by the floating pollen, after which the spiral stalk coils up again and conveys the flower to the bottom of the water.

The leaves of the *Vallisneria* form an exceedingly beautiful object under the microscope, the extreme tenuity and transparency of their cellular tissue allowing the observer to watch the movement of the fluid contents of the cells.

Some botanists have proposed to separate this and one or two allied genera from *Hydrocharidaceæ*, under the name of *Vallisneriaceæ*.

Vallum (Lat.). The name given to the wall or fortifications of a Roman camp. It was made, properly, of *valli* or stakes, and was thus a palisade run along the outer edge of the summit of the *agger* or rampart, raised by the earth excavated in order to form the *fossa* or trench, which ran round the agger. Each Roman soldier carried three or four of the valli, which were used in constructing the palisade.

Valonia. The cup of the acorn of *Quercus Ægilops*, imported from the Levant and the Morea. It is an important tanning material.

Valorem, Ad (Lat.). In Finance, a term employed to denote the market value of commodities imported and liable to a customs rate, whether it be that the duty is levied on articles which, being uniform in quality, vary from year to year in consequence of the demand being generally equal, but the supply uncertain, or which are different in quality though similar in character. Thus, for instance, the Ionian Islands levy an ad valorem duty on currants; the estimate being taken from the market value of the exported article. Such a value must vary with the largeness or smallness of the crop. On the other hand, the English customs acts levy an ad valorem duty on sugar; the import on the finer kinds being more than that on the coarser article, and most on that which is refined. When the article is not open to an obvious or easy test, some police arrangements are necessary, by which, as a rule, the object of the tax may be, in order to obviate fraud, put up to auction, or even sold at the price fixed on it by the importer.

As a rule, ad valorem duties are unsatisfactory on the ground of uncertainty. They have seldom been successful. On primâ facie grounds, it seems desirable, for instance, to tax high-priced wines at larger rates than cheaper goods; but it was felt that any attempt to introduce such a sliding scale of duties would be objectionable, and would be probably evaded. Even the sugar duties are the object of incessant attack. For the principle on which the government interprets average values of imports, see the *Commercial Dictionary*, art. 'Average in Imports.'

Value. In Political Economy, the estimate given of any commodity in contrast with all other commodities, and differing from price, which is the estimate given of any commodity by one value only, i.e. the value of the precious metals. There can be a general rise in prices, since the value of the single measure may fall: there cannot be a general rise in values, for values are relative and mutual. There may be, of course, a great rise or fall in the value of any one thing when it is scarce and in demand, or abundant and neglected. There cannot be a universal rise in values, or a universal fall in values, for if such a case could be for a moment conceived, no one would get any more in the first case, or any less in the second.

Economists distinguish value in use from value in exchange, the contrast between the two senses having been instituted by Adam Smith. (*Wealth of Nations*, book i.) By value in use, is understood the necessity of the object; by value in exchange, the demand for the object and its cost of production. Thus, the use of air and water is of the highest kind. But ordinarily there is no value in exchange assignable to these objects, unless indeed they are naturally limited and labour is expended on producing or supplying them. Thus, in a deep mine, or in a diving bell, air may possess a value in exchange, as in a populous city the supply of water always does. But food, however plentiful, is always possessed of value in exchange, because it is in demand, is limited in quantity, and must always be produced by labour.

Adam Smith is, however, not always consistent in his distinction, because he confounds use in the sense of moral utility or physical necessity, with the individual's use, as signified in demand. Thus, he says, a diamond has no value in use, but great value in exchange. It may have no use to wise persons, and if all persons were wise, it might have no value in exchange; but because it is demanded, it has a use, which the individual appreciates, and on the basis of which he admits its value in exchange. It is with value in exchange, or exchange value, only, that economists are concerned.

It will be seen, then, that the value of any given commodity or service is affected by two causes, one of which is temporary, viz. demand, and the other permanent, viz. the cost of production. In the long run, a particular value conforms to the last-named cause, but from time to time it is regulated by demand and supply, and may therefore rise and fall far above or far below the cost of production. From the fact that demand and labour determine values, some economists have insisted that the first of these causes is the true measure of value, while others maintain that value is determined by the second. Both are determining causes, but under different circumstances; and the statements, that labour is the cause of value, and demand is the cause of value, are, though apparently repugnant, two

phases of the same fact. [DEMAND; POLITICAL ECONOMY; PRICE; SUPPLY.]

Valvata (Lat. valvæ, *folding doors*). A genus of fresh-water snails or Gastropods; so called from the valve-like form of the operculum or lid which covers the aperture of the depressed spiral shell. Of this genus several species are British; as *Valvata obtusa*, common in the ditches at Battersea; *Valv. spirorbis*, *Valv. planorbis*, *Valv. minuta*, &c.

Valvate (Lat. valvæ). In Botany, a term applied to parts which are united by the margins only; as the sepals of rhamnads, or the valves of a capsule.

Valve (Lat. valva). A contrivance for opening and closing an orifice, either by spontaneous action or by external interference. Among the many varieties of valves employed in mechanics may be mentioned the *slide* or *sluice valve*, where the orifice is opened by drawing up a plate; the *flap valve*, which opens and shuts like a door; the *pot-lid valve*, where the orifice is closed by shutting down upon it a disc of metal; the *ball valve*, where the orifice is closed by a ball; and the *throttle valve*, where a disc of metal turning on a spindle passing through its edge may be made to stand across a pipe, and so close the opening. [STEAM ENGINE.]

Valves (Lat. valvæ). In Botany, the pieces into which the fruit of a plant naturally separates when it bursts. The name is also applied to similar parts in any other organ, as the anther.

Vambrace (Fr. avant-bras). The defence of plate armour worn on the forearm, in the suits of the fifteenth and sixteenth centuries. The covering of the upper arm was called the *rerebrace*, from the French arrière bras.

Vampire (Ger. vampyr). A blood-sucking spectre, the object of superstitious dread among various nations of Europe. The belief in vampires—i.e. in persons returning to the earth after death and burial, not as ghosts, but in actual corporeal substance, and sucking the blood of living men—appears to have prevailed in very ancient times. The Empusæ, Lamiæ, and Lemures were species of vampires. One of the most detailed stories of vampires is the tale which Goethe has made the foundation of his poem of the *Bride of Corinth*, in which the dead bride of a young man visits him at night, and withers him by her embrace. But in modern Europe, the populations among which vampire superstitions have prevailed appear to be of Slavonic descent. The word *vampire* is said by Adelung to be of Servian origin: and although the modern Greeks have also their vampires, yet the barbaric names by which they call them (Vroucolachas, Vuroulachas, Vardoulachas) seem rather to indicate a Slavonic, or perhaps Albanian source, for both the tradition and the word. In Crete they are called Katakhanàs, and firmly believed in. (Pashley's *Travels*.) About a century ago, there prevailed in several districts of Hungary an epidemic dread of vampires, which lasted some years, and gave birth to many extraordinary stories. It was believed that in several places those among the dead who belonged to the class of vampires arose nightly from their graves and sucked the blood of the living, who fell into consumptions and perished; that those who had died in this manner became infected with vampirism; and that the only way of exterminating the plague was by disinterring all the suspected vampires, and if it were discovered that they exhibited the tokens of their hideous character, burning them to ashes, or driving a stake through their middle. The attestations which these grotesquely fearful tales received are among the most singular instances of human credulity recorded in all the annals of superstition. [RATIONALISM; WITCHCRAFT.] They are, in many instances, related on the authority of the pastors and other most credible persons of villages and towns, who depose to having been themselves witnesses of the scenes beheld on opening the vampires' graves. Some, indeed, had actually seen the spectres themselves on their nightly excursions; but more generally the attestations are by persons present at the inspection of the dead bodies, when, if the subject was a true vampire, he was generally found of a florid and hale complexion; his hair, beard, and nails had grown; his mouth, hands, &c. were stained with fresh blood; his eyes open and brilliant. Sometimes, when the stake was driven through him, he was heard to utter cries like those of a living person. It was believed that the consumption produced by the sucking of the vampire could be cured by eating earth from his grave. The popular name of the vampire-bat (*Vespertilio spectrum*), a small animal of South America which sucks the blood of persons asleep, is derived from these imaginary monsters.

Vamplate (Fr. avant-plat). A large piece of plate armour of the sixteenth century, used in jousting to supply the place of arm and hand defence to the wearer, protecting him more effectually against his opponent's lance. Specimens may be seen in the armoury of the Tower of London, the Rotunda at Woolwich, &c. An excellent drawing and description of one is given in the *Archæological Journal*, vol. xxiii. 1866.

Van (Fr. avant, from Lat. ab, and ante). In Naval language, the foremost division of the line of battle, which is also the weather division when the fleet is on a wind.

Vanadinite. Native vanadiate of lead. A mineral found at the Susannah mine, at Wanlock Head, in Dumfriesshire, &c.; in small hexagonal prisms, but generally in implanted globules, or incrustations of a yellowish or reddish-brown colour. [VANADIUM.]

Vanadium. A metal discovered in 1830 by Professor Seftström of Fahlun, in iron prepared from the iron-ore of Taberg in Sweden. Vanadium has also been found in a lead-ore from Wanlock Head in Scotland, and in a

similar mineral from Zimapan in Mexico. Vanadium is a white brittle metal, very difficult of reduction; not oxidised by air or water; and insoluble in sulphuric, hydrochloric, and hydrofluoric acids, but soluble in nitric and nitro-hydrochloric acids, with which it yields solutions of a fine dark blue colour. It is not acted upon by boiling caustic potash, nor by the carbonated alkalies at a red heat. The peroxide of vanadium is of an orange colour, and very slightly soluble in water; it unites with the salifiable bases; with the alkalies its salts are soluble, with the other bases sparingly soluble. These salts are orange or yellow coloured; in these and other respects there is a close resemblance between vanadium and chromium. Peroxide of vanadium, or vanadic acid (VO_3), is distinguished from chromic acid by the action of deoxidising substances, which give a blue solution with vanadium, but a green one with chromium. When heated with borax in the reducing flame of the blow-pipe, both of the acids yield a green glass; but in the oxidising flame the bead becomes *yellow* if vanadium is present, but the green colour is permanent if produced by chromium. According to the experiments of Berzelius, the equivalent of vanadium is about 68; and the protoxide, the deutoxide, and the vanadic acid are composed respectively of 1 atom of vanadium, and 1, 2, and 3 of oxygen. It forms two chlorides, VCl_2 and VCl_3.

Vane (Dutch vaan). A contrivance for showing the direction of the wind. It consists usually of a thin slip of wood or metal, attached to a perpendicular axis, round which it moves freely; and is so shaped that it presents always the same extremity to the point of the horizon from which the wind blows.

Vanellus. A name applied by Bechstein to a subgenus of the Linnæan *Tringæ*, including the true lapwings, which are distinguished from the *Squatarolæ* of Cuvier by their more distinct, though small, hinder toe, and their partially scutellated tarsi.

Vanessa (or better *Phanessa*, from Phanês, a mystic divinity in the Orphic rites, also known as Eros, Ericapaios, and Protogonos). This term is applied to a genus of butterflies, in which the inferior palpi are contiguous in their whole length, terminating gradually in a point, and are much compressed.

Vang. A rope passing from the extremity or peak of a gaff to each of the ship's sides, for the purpose of steadying the spar.

Vanga. A name used to denote a species of birds which are by some combined with the crows, as part of the conirostral tribe. They are characterised by a large bill, greatly compressed throughout, the point of the upper mandible suddenly curved, and the under mandible bent upwards.

Vanguard (Fr. avant-garde). That part of an army which precedes the main body on the march, as a security against surprise.

Vanilla (Span.). The succulent fruit of *Vanilla planifolia*, and perhaps of other species. These are plants of the Orchidaceous order, climbing over trees in the tropical parts of America after the manner of ivy. The fragrance of the fruit is owing to the presence of benzoic acid, crystals of which form upon the pod if left undisturbed. It is an aromatic, employed in confectionery and the preparation of liqueurs, and in flavouring some kinds of chocolate, &c. This is, perhaps, the most important genus of the whole Orchidaceous family, and the only one which possesses any marked economical value. The best Vanilla is the produce of *V. planifolia*, a native of Mexico, but several other South American species are also used. About five or six cwt. are annually imported into this country.

Vanishing Fractions. [Fractions.]

Vanishing Groups, Method of. In Algebra, a method of reducing an algebraic function to the form of a sum of like powers, grouping the powers two and two together, and making each group vanish. One of the most interesting applications of the method is that by which the general algebraic equation of the n^{th} degree (n being greater than 4) can be deprived of its second, third, and fourth terms, simultaneously, by the solution of auxiliary equations, some of which rise above the third degree, or of its second, third, and fifth terms by the aid of equations, none of which rise above the fourth degree. In this way, the general equation of the fifth degree can, by the aid of equations of inferior degrees, be reduced to a trinomial form. The method, however, admits of other applications, as pointed out by its inventor, Mr. James Cockle. (*Cambridge and Dublin Math. Journal*, vols. ii. iii. vi. 1847–51.)

Vanishing Point. [Perspective.]

Vapour (Lat. vapor, perhaps akin to Gr. *καπνός*). When liquids and certain solids are heated they become converted into elastic fluids or *vapours*, which differ from *gases* in this respect, that they are not under common circumstances permanently elastic, but resume the liquid or solid form when cooled down to ordinary temperatures. The term *vapour* is frequently limited to water in the state in which it exists in our atmosphere and in other humid aëriform bodies, i. e. in a perfectly invisible state.

Different substances yield vapours with very different degrees of facility, or, in other words, are more or less volatile; a circumstance dependent, probably, upon the less or greater cohesion with which their particles adhere. Hence fluids are generally more volatile than solids, and hence solids generally pass into the liquid state before they assume the form of vapour. To both these statements there are, however, many exceptions; thus most of the expressed oils, being soluble only with great difficulty, are hence termed *fixed oils*. Common concentrated sulphuric acid is also a very fixed liquid, requiring a high temperature for its vaporisation; and camphor and some other solids evaporate at common temperatures, and arsenic and sal ammoniac at moderately high

temperatures, without previously assuming the liquid state. The space which vapours occupy always exceeds that of the substances from which they arise. Thus, at the temperature of 212°, and under a pressure of 30 inches of mercury, a cubic foot of water produces 1696 cubic feet of vapour, of alcohol 660, and of ether 443. Hence it is obvious that different vapours differ very considerably in density, and that this property is not directly as that of the liquids which furnish them. Thus, if we assume the density of air as 1000, that of aqueous vapour or steam is only 625; the density of aqueous vapour to that of atmospheric air being as 1000 to 1694. Again, assuming the density of air as = 1000, that of alcohol vapour is 1613, and of ether no less than 2586; though alcohol and ether are both, in the liquid state, lighter than water.

All vapours follow very nearly the same law of expansion, when heated, as gases, i.e. for every degree of Fahrenheit's thermometer they increase by $\frac{1}{491}$ of the volume which they occupied at 32°; but near their condensing points this coefficient becomes somewhat greater.

VAPOUR. In Physics, this term denotes the condition of a body when, its particles having acquired a repulsive force by the accession of heat, it is expanded to the state of an elastic fluid. Every liquid possesses the property of boiling at a certain determinate temperature, under the mean pressure of the atmosphere. Water, for example, boils at the temperature of 212° of Fahrenheit's scale, when the pressure of the atmosphere is equal to a column of mercury 30 inches in height; but under a diminished pressure it boils at a lower temperature; and by increasing the pressure, the temperature of the boiling point is increased. In the course of ebullition an elastic fluid, or vapour, is generated; and it is only when the tension of the vapour becomes equal to the pressure, that the action of boiling begins. But though ebullition and the consequent rapid formation of vapour take place only at a given temperature under a given pressure, vapour will rise from the surfaces of all liquids in free contact with the atmosphere at much lower temperatures. Water, for example, exposed in an open vessel, undergoes a gradual diminution of bulk, and is dissipated at temperatures far below the boiling point; and ice itself soon wastes away in the same insensible manner. This dissipation has been shown by Dalton to be occasioned by the formation of vapour of the same temperature as that of the water from which it proceeds, and having an elastic force equal to that of the vapour of water boiling at that temperature under a diminished pressure. Some liquids, ether for instance, require to be carefully secluded from the atmosphere to prevent their rapid evaporation.

Tension of Vapour at different Temperatures.—Dr. Dalton of Manchester was the first who ascertained by accurate experiments the elastic force of vapours at different temperatures below that of the point of ebullition. (*Manchester Memoirs*, vol. v. 1802.) The method which he employed consisted in introducing a portion of liquid into the vacuum of a barometer, where it floats on the surface of the mercury, and part of it is immediately converted into vapour. The tension of the vapour causes the mercury to descend; and the force of the tension is measured by the space through which the mercury falls, or by the difference of the height of the mercury in the tube in which the experiment is performed and its height in the common barometer. Dr. Dalton employed two barometric tubes plunged in the same cistern of mercury. Into one of these the liquid furnishing the vapour was introduced, the other serving the purpose of comparison; and in order that the experiment might be made at any determinate temperature, the two tubes were surrounded by another wider tube, into which water was poured of the temperature required. When the liquid on which the experiment was made was water, and the water surrounding the two barometric tubes was at the temperature of ebullition, the vapour formed in the tube caused the mercury to descend to the level of that in the cistern; whence it was inferred that at the temperature of ebullition the elastic force of aqueous vapour is precisely equal to the atmospheric pressure. A similar result was obtained when the experiment was performed with other liquids.

If the tube containing the portion of liquid be of considerable length, and the basin in which it is inverted of considerable depth, the pressure on the vapour above the mercury may be varied by raising or lowering the inverted tube. When the pressure is diminished in this way, it is found that so long as any liquid remains, new vapour of the same degree of tension will be generated, and the altitude of the mercury in the tube remain constant. On the other hand, an increase of pressure causes the condensation of a part of the vapour, and the mercury in the tube stands at the same height above that in the cistern. If the quantity of liquid in the barometric tube be so small that the whole is converted into vapour, it will be found that, on raising the tube and increasing the space in which the vapour is contained, the elastic force diminishes in proportion as the space is increased. The law of Boyle, therefore, applies to vapours as well as to the permanent gases [PNEUMATICS]; but with this distinction, that the vapours of all liquids, at a certain determinate temperature, have a maximum of density and tension which cannot be exceeded, and on attaining which they are condensed into the liquid form by any attempt to compress them further. It follows, therefore, that at a given temperature no more than a limited quantity of vapour can exist in a given space. This forms the criterion which distinguishes vapours from the permanent gases.

The results obtained by Dalton, in his experiments on the tension of aqueous vapour, are exhibited in the following table (*Manchester Memoirs*, 1802):—

Table showing the Maximum Tension of Aqueous Vapour at Temperatures below 212°, estimated in the Height of the Column of Mercury which they are capable of supporting.

Temperature	Tension in Inches of Mercury	Temperature	Tension in Inches of Mercury	Temperature	Tension in Inches of Mercury
2°	0·068	77°	0·91	152°	7·81
7	0·082	82	1·07	157	8·81
12	0·096	87	1·24	162	9·91
17	0·116	92	1·44	167	11·25
22	0·139	97	1·68	172	12·72
27	0·168	102	1·98	177	14·22
32	0·200	107	2·32	182	15·86
37	0·237	112	2·68	187	17·80
42	0·283	117	3·08	192	19·86
47	0·339	122	3·50	197	22·13
52	0·401	127	4·00	202	24·61
57	0·474	132	4·60	207	27·20
62	0·560	137	5·29	212	30·00
67	0·655	142	6·05		
72	0·770	147	6·87		

From this table the following formula for the elastic force or tension (which is measured by the pressure p) in terms of the degrees of temperature t, reckoned from 32°, has been deduced, which nearly represents the table, viz.

$$p = \cdot 1718\ (1 + \cdot 006\ t)^7.$$

In order to determine the tension of vapour at a temperature above the boiling point, it is necessary to have recourse to a different method of experimenting. By far the most satisfactory experiments hitherto made on this subject are those of Dulong and Arago in 1830, and of Regnault in 1844. As an account of these experiments, and a table of the results, have already been given in art. STEAM, it is here only necessary to remark, that the relation between the pressure and temperature (at least for all pressures exceeding four atmospheres) was found to be represented very nearly by the following empirical formula, viz.

$$p = (1 + 0\cdot 003974\ t)^5,$$

in which p denotes the tension or elasticity expressed in atmospheres, and t the degrees of temperature of Fahrenheit, counting from 212°.

It is evident from this empirical formula, as well as the numbers in the tables, that the tension of aqueous vapour increases in a much faster ratio than the temperature. This result appears to be general, and applicable to the elastic force of the vapours of all liquids, at least so far as may be judged from the imperfect experiments which have hitherto been made on the vapours of mercury, alcohol, and ether. Dalton thought that he had discovered a law which would establish a very simple relation among the tensions of the vapours of different liquids. It consists in this, that at an equal number of degrees above or below the point of ebullition corresponding to each liquid the elastic force of their vapours is equal. Thus, water boils at 212°, alcohol at 175°, and ether at 100°, the tension of the vapour at the boiling point being in all cases the same, and equal to the pressure of the atmosphere. Now, from the experiments of Dulong it appears that the tension of aqueous vapour is doubled when heated under pressure to 251°; i.e. by an increase of temperature of 39° above the boiling point. Hence, by the law of Dalton, the tension of the vapour of alcohol is equal to two atmospheres when its temperature is 175° + 39° = 214°; and that of ether equal to two atmospheres when the temperature is 100° + 39° = 139°. Dalton himself afterwards discovered that this law fails when the distances from the point of ebullition are considerable.

Density of Vapour.—The density of a vapour may be determined by introducing a known weight of the liquid which yields it into a receiver containing mercury, and inverting the receiver in a vessel also containing mercury, and tall enough to contain, above the mercury, a sufficient depth of water to cover the receiver. The whole apparatus is then heated; and when all the liquid in the inverted receiver has been evaporated, the space which the vapour occupies is measured, whilst at the same time the temperature of the surrounding water is noted. We have then a given bulk of vapour, the weight of which is the same as that of the liquid from which it has been produced, and consequently known. The temperature is also known; and the pressure is given in terms of the column of mercury in the receiver, and the height of the surrounding fluid compared with the indication of the barometer. In this manner the density is found; and when the density of a vapour at a given temperature and under a given pressure has been determined, its density under any other pressure, and at its corresponding temperature, may be calculated in the following manner: Let a = the constant coefficient of dilation = ·00204 (it being found by experiment that vapour out of contact with liquid expands or contracts at the same rate with permanently elastic fluids by variations of temperature, i.e. by $\frac{1}{491}$ of its volume for each degree of Fahrenheit's scale), t = the number of degrees of Fahrenheit's thermometer above 32°, v = the volume, p = the pressure, and d = the density of a vapour at the temperature of 32°; and let v', p', and d' be respectively the volume, pressure, and density at another temperature, 32° + t. We have then $v' = (1 + a\,t)\,v$. Now, when the pressure is constant, the density is inversely as its volume; and, by the law of Boyle, the density of a gas or vapour is directly as the pressure; whence $\frac{d'}{d} = \frac{p'}{p} \times \frac{v}{v'}$, and consequently $\frac{d'}{d} = \frac{p'}{p(1 + a t)}$, or $d' = \frac{d\,p'}{p(1 + a t)}$. If we compare the density of aqueous vapour at any temperature with its density at the boiling point of water, which is 180° above the freezing point, and put d'' = the density, and p'' = the pressure at the boiling point, the formula becomes $d' = \frac{d''\,p'\,(1 + 180\,a)}{p''\,(1 + a\,t)}$. The following table, computed from this formula,

with Dalton's values of the pressures, shows the density and volume of aqueous vapour, at its maximum tension, for every ninth degree of temperature from the freezing to the boiling point. The unit of density is water at the temperature of 32°; and the unit of volume the volume of an equal weight of water also at 32°. As the density is inversely proportional to the volume, the numbers in the last two columns are the reciprocals of each other. They differ slightly from the numbers given by Gay-Lussac.

Temperature	Density	Volume
32°	·0000053	188600
41	·0000073	137000
50	·0000097	103000
59	·0000131	76330
68	·0000173	57800
77	·0000227	44050
86	·0000297	33670
95	·0000390	25640
104	·0000499	20030
113	·0000637	15690
122	·0000810	12350
131	·0001022	9784
140	·0001261	7930
149	·0001592	6281
158	·0001964	5091
167	·0002388	4187
176	·0002936	3406
185	·0003557	2811
194	·0004261	2346
203	·0005074	1971
212	·0005896	1696

By means of this table we may calculate the weight of water that would be contained in the form of vapour of the maximum tension in any given volume—a calculation which is frequently required in meteorological enquiries.

The phenomena of vapour have been studied with reference to two objects; the condition of the atmosphere as to moisture, and the properties of steam as a moving power in machinery. On the subject of vapour in connection with the first of these objects, see Daniell's *Meteorological Essays*; Davy's *Elements of Agricultural Chemistry*. [Dew; Evaporation; Hygrometry.] See also *Greenwich Meteor. Obs.* For experiments on the elasticity and density of aqueous vapour, see, in addition to the Memoirs of Dalton and of Arago and Dulong, already cited, Robinson's *Mechanical Philosophy*; Ure, in the *Philosophical Transactions* for 1818; Pouillet, *Traité de Physique*; Despretz, *Traité de Physique*; Gheler's *Physikalisches Wörterbuch*, art. 'Dampf,' by Prof. Muncke. [Steam.]

Varangians. A name employed by the Greek historians to designate the Teutonic guards of the Byzantine emperors. The name, which passes through the Low Latin forms wargus, wargengus, warengangi, &c., has by some been traced to the old Teutonic *varg*, a wanderer or exile, while others suppose it to be the same with *Franks*. Harald Hardrada, king of Norway, who fell at the battle of Stamford Bridge, had served among the Varangians at Constantinople; and after the Norman conquest of England their ranks were, according to the statement of Ordericus Vitalis, recruited by numbers of Englishmen who found their way into the Byzantine territories. (Thierry, *Conquête de l'Angleterre par les Normands*, livre v.)

Varec. The impure carbonate of soda, made in Brittany: it is also sometimes called *Blanquette*: it corresponds to our *Kelp*.

Variable Quantity. In Analysis, a quantity conceived to be in a state of increase or diminution, or to have different values in the same equation. Thus, the abscissa and ordinates of a curve are variable quantities, because they have different values for every different point in the curve, and in passing from one point to another their values increase or diminish according to the law of the curve. In the equation of the circle $y = \sqrt{(2\,a\,x - x^2)}$, x and y are variables; for x may have any value whatever between 0 and $2\,a$, and there will be a corresponding value of y, which satisfies the equation. The quantity a is a *constant* quantity, and remains the same, whatever be the values of x and y. It represents, in fact, the radius of the circle.

Variance (Lat. variantia). In Law, a difference of statement between two material documents in a cause; as where the plaintiff's declaration differs from a deed on which it is grounded. Accidental slips of this nature were formerly often fatal, but the courts have now power to amend variances, and this power is so liberally exercised that the subject has lost much of its importance.

Variation (Lat. variatio). In Music, a different manner of performing the same air or melody. Airs with variations have always been favourite subjects for composition, and the works of almost all eminent musicians abound in examples of varied airs, showing great musical skill.

Variation of the Compass. The angle which the magnetic needle makes with the plane of the true meridian. It is otherwise called the *declination*. [Declination of the Magnetic Needle.] For tables showing the variation of a great number of places, and its progressive, annual, and diurnal changes, see Brewster's *Treatise on Magnetism*, 1837, reprinted from the *Encyclopædia Britannica*, and *Greenwich Magnet. Obs.*

Variation of Curvature. In Geometry, the change which takes place in the curvature in passing from one point of a curve to another. The circle is the only curve in which the curvature is the same at every point. The curvature of a curved line at any point is the same as that of the osculating circle at that point. But the curvature of a circle is inversely as its radius: hence the curvature of any curve is

inversely proportional to the radius of curvature; and, consequently, the variation of the curvature is proportional directly to the differential of the radius, and inversely to the square of the radius of curvature. In the conic sections, the variation of curvature at any point is proportional to the tangent of the angle included between the diameter and the normal, which pass through that point.

Variation of the Moon. In Astronomy, an inequality of the moon's motion, depending on the angular distance of the moon from the sun. It arises from that part of the sun's disturbing force which is at right angles to the radius vector, and which accelerates the motion of the moon from the quadratures to the syzygies, and retards it from the syzygies to the quadratures. It is proportional to the sine of twice the angular distance between the sun and moon; and its maximum value, or the coefficient of its arguments, is 35′ 41·9″. Hence it is represented by the formula (35′ 41·9′) sin 2 A, A being the angular distance of the moon from the sun. The variation was discovered by Tycho Brahe. It had escaped the observation of Hipparchus and the ancient astronomers, though of sufficient magnitude to have been sensible to them; probably because they chiefly observed the moon in the syzygies and quadratures, and at these points of the orbit its value is nothing.

Variation of Parameters. [PARAMETERS, VARIATION OF.]

Variations. In Algebra, the different *arrangements* of a set of objects into groups of given magnitude, which differ either in the objects which they contain or in the order in which these objects are arranged. The term *permutation* is sometimes used in place of variation, though by permutations are generally understood variations each of which contains all the objects. [PERMUTATIONS.] The number of variations, m in each, of n different objects is the product of the m successive factors $n\ (n-1)\ .\ .\ .\ (n-m+1)$. Thus, there are $3 \times 2=6$ variations of three letters a, b, c, when taken in pairs; they are ab, ba, ac, ca, bc, cb. Combinations differ from permutations inasmuch as the order of the objects in each group is disregarded. [COMBINATIONS.] Hence each permutation of a combination is a variation, and the three are connected by the simple relation C . P = V, where C and V are, respectively, the numbers of combinations and variations that can be formed from n things by taking m together, and P the number of permutations of m things. With a sufficient supply of each of the n different objects n^m different variations, m in each, can be formed, provided objects of the same kind may also enter into a variation.

Variations, Calculus of. An important branch of Modern Mathematics, developed by Lagrange, the principal object of which is to resolve in a general manner certain classes of questions respecting *maxima* and *minima*, the solution of which cannot be obtained by the ordinary processes of the differential calculus. In solving problems of maxima and minima by the differential calculus, it is necessary to find the determinate values of the different variables which enter into a proposed finite function of those variables, in order that the proposed function may have the greatest or least value possible. Many problems of this nature are met with in the writings of the ancient geometers, particularly in the Conics of Apollonius; and the application of algebra to geometry gave rise, about the middle of the seventeenth century, to many others, proposed and solved by Fermat, Slusius, Hudde, and others. As no general method of solving such questions was known before the invention of the differential calculus, their solution was accomplished by particular artifices, and was frequently attained with very considerable difficulty. This difficulty was removed for the class of questions now mentioned by the invention of the calculus; but as the instrument of investigation was improved, new views were opened, and a more difficult class of questions was proposed, to which the known methods seemed inapplicable. It was proposed to find, among all curves subjected to a given law, that which best fulfilled a given condition: for example, to find the curve which, under given conditions, encloses the greatest space; to find the curve along which a heavy body must descend in order to pass from one given point to another given point in the least time possible, &c. In such questions the relations between the variables is not given, as in the ordinary cases of maxima and minima; the object proposed being to find that relation, or to find the equation which must subsist between the variables in order that the condition of maximum or minimum may be fulfilled.

The first problem of this kind which was solved appears to have been that of the solid of least resistance. In the first edition of the *Principia*, published in 1687, Newton gave the equation of the curve by the rotation of which about its axis that solid is formed which, when moved through a fluid in the direction of the axis, is less resisted than any other body of the same specific gravity and bulk; but he did so without demonstration or indication of the views by which he had been guided. About ten years later the famous question of the BRACHISTOCHRONE, or curve of quickest descent, was agitated between the two brothers James and John Bernoulli, in which Leibnitz and some of the other most illustrious mathematicians of the day took a part. The more general problem of *isoperimeters* was solved by James Bernoulli in 1701; and it was in the analysis which he gave on this occasion that the principle on which the solution of similar questions depends was first distinctly unfolded. Euler treated the whole subject in his peculiarly luminous manner in a treatise published in 1744, under the title *Methodus Inveniendi Lineas Curvas Maximi Minimive Proprietate Gaudentes*. And,

lastly, the method was reduced to its utmost simplicity by Lagrange, who supplied the algorithm, and gave to it the form under which it is now exhibited as the Calculus of Variations.

We shall confine ourselves here to the briefest possible statement of the first principles of the calculus, and then refer the reader to the best works on the subject. The differential calculus investigates the changes which a function undergoes when the variables of that function receive infinitesimal increments; the more especial object of the calculus of variations, however, is the investigation of the change which a function suffers when its *form* is altered. The form of a function u being conceived to change continuously, the change in its value, due to an infinitesimal change in form, is denoted by δu, and called its *variation*, just as its change in value due to infinitesimal changes in the values of its variables is denoted by du, and called its *differential*.

One of the principal objects of the calculus is to find the variations of integrals of given expressions, and the forms which the indeterminate functions involved in those integrals must have in order that the latter may possess maximum or minimum values. In solving such problems the following two important principles are frequently applied: The variation of a differential is equal to the differential of a variation, and the variation of an integral (which must vanish for maximum or minimum values) is equal to the integral of a variation. These principles are expressed by the symbolical equations $\delta d = d\delta$ and $\delta\int = \int\delta$.

The complete treatises on the subject are those of Jellet (Dublin 1850); Strauch, *Theorie und Anwendung des sogenannten Variations-calcul's*, Zurich, 1854 (distinguished by its rich collection of worked examples); Stegmann, *Lehrbuch der Variations-rechnung* (Kassel 1854); and the *Calcul des Variations*, now publishing by Moigno and Lindeloef. We have also, in English, two excellent critical histories of the calculus: the first, by Woodhouse, is entitled *A Treatise on Isoperimetrical Problems and the Calculus of Variations* (Cambridge 1810), and gives the history of the calculus from its origin to the close of the last century; the second, by Todhunter (Cambridge 1861), gives a very complete account of the progress made during the present century. These works will furnish the reader with full references to the many important investigations on the subject.

Varicella. [CHICKEN-POX.]

Varicocele (a word coined from the Lat. varix, *a distended vein*, and Gr. κήλη, *a tumour*). A swelling of the veins of the spermatic cord.

Variegated Copper-ore. [ERUBESCITE.]

Variety (Lat. varietas). In Zoology, this term is applied to individuals of the same species, which, from the operation of different causes, as age, climate, food, locality, domestication, &c., present deviations from the specific type in size, colour, form, and relative proportion of parts of the body; but have the capacity of reverting to the original specific form in successive generations, on the cessation of the influences under which the variety originated.

Variola. [SMALLPOX.]

Variolite. A variety of Felspar, generally of a dark green colour speckled with grey; but sometimes exhibiting white, blue, red, and other intermediate tints. The name (from variola, the smallpox) has reference to the remarkable appearance presented by weathered surfaces of the stone, which display projecting black spots or points, each surrounded by a brown (sometimes by a white) ring, and occasionally even by a second whitish circle. Large masses of this stone are obtained from the High Alps, and it is also found in France, Switzerland, Savoy, and in co. Antrim, Ireland. Variolite takes a beautiful polish, and is used in that state for ornamenting cabinets, for caskets, snuff-boxes, &c.

Variolous. In Zoology, when a part is beset with many shallow impressions like marks of the variola or smallpox.

Variorum Editions. In Bibliography, certain editions of the classic authors of antiquity, published chiefly in Holland, in the seventeenth and eighteenth centuries, and containing the notes of numerous commentators. These editions are chiefly valued by collectors.

Variscite (from Variscia, the Latin name for Voigtland). An apple-green mineral forming a reniform incrustation on flinty slate at Messbach in Voigtland.

Varix (Lat.). A dilatation or swelling of a vein.

Varnish (this word may perhaps be another form of *burnish*; but Sir G. C. Lewis gives the following account of the term: Upon the return of Ptolemy Euergetes, king of Egypt, from his Syrian expedition in 243 B.C., his Queen Berenice dedicated a lock of her hair in the temple of Aphrodite at Zephyrium; this lock, having disappeared from the temple, was translated by Conon into the heaven as a constellation, which bears the name of Coma Berenices, and its fame has been perpetuated in the word *vernice*, *vernis*, and *varnish*, which alludes to the amber colour of the queen's beautiful tresses: *Astronomy of the Ancients*, ch. iii. sect. 14). A fluid which when spread thin upon a solid surface becomes dry, and forms a coating impervious to air and moisture. There are two kinds of varnish; viz. *spirit* and *oil varnishes*: methylated spirit is used for the former; and for the latter, fixed and volatile oils, or mixtures of the two. The solid substances which are dissolved in the above menstrua, and constitute the *body* of the varnish, are almost exclusively resinous, and are chiefly the following: 1. *Turpentine*, all the varieties of which are employed by the varnisher: they form an excellent body, and give strength and glossiness at a small expense; but they do not dry without other additions. 2. *Copal*, a peculiar resin, very diffi-

cult to dissolve, but forming a hard and durable ingredient. It is generally melted over a gentle fire previous to use. 3. *Lac*, which gives great toughness and hardness; but is often inadmissible, on account of its reddish brown colour. 4. *Mastic*, which yields a tough, hard, brilliant, and colourless varnish. 5. *Elemi*, a resin of a pale yellow green tint, and a valuable ingredient, on account of its toughness and durability. 6. *Sandarach*, a resin which imparts splendour, but which alone is not durable. 7. *Amber*, a valuable ingredient, on account of its hardness and durability; but difficult of transparent solution, and hence chiefly used in opaque varnishes. 8. *Benzoin*, added on account of its fragrancy. 9. *Anime*, which gives brilliancy and some scent. 10. *Gamboge*, for yellow varnishes. 11. *Dragon's blood*, for red varnish. These, together with turmeric, saffron, and annatto, are used chiefly on account of their colour, and to cover brass and copper under the name of *lacquers*. 12. *Caoutchouc*. This extraordinary vegetable product has of late been much employed in a variety of preparations used as varnishes. It is invaluable where materials are to be rendered air-tight, and where at the same time flexibility, and even elasticity, are required; but its principal application in this way is in the manufacture of various *waterproof* articles. 13. *Asphaltum*, the varieties of which are indispensable in black oil varnishes. In making spirit varnishes, the strongest methylated spirit of commerce should be used (of a specific gravity not exceeding 820), and its solvent power over some of the more intractable resins is sometimes improved by the addition of a little camphor; in order to prevent the agglutination of the resin, it is often necessary to mix it with sand or pounded glass, by which the surface is much increased, and the solvent energy of the spirit facilitated. The proportions in which the several ingredients are used, and the selections for particular purposes, are infinitely various.

Varuna. [URANUS.]

Varvicite. An ore of manganese found in slightly radiating, fibro-lamellar masses, of a steel-grey colour and a sub-metallic lustre, at Hartshill in Warwickshire. It is probably a mixture of Pyrolusite and Psilomelane or Manganite; the former of which it resembles in hardness, and the latter in appearance. 'The name was devised by the late Richard Phillips, to facilitate the pronunciation by foreigners of the word *Warwick* (*Varvic*), the locality after which the mineral was called.' (Bristow's *Glossary of Mineralogy.*)

Vascular System (Lat. vascularius, from vasculum, dim. of vas, vasis, *a vessel*). In Botany, that portion of the tissue of plants which is destined for the conveyance of air. Vascular plants are those in which the vascular system occurs, or forms a principal feature. The air-vessels are the tracheæ or spirals.

Vase (Lat. vas, vasis). In Sculpture, a vessel usually ornamented with sculpture of fruits, flowers, bassi-rilievi, &c.

Vases, Etruscan. In Antiquities, these well-known and beautiful objects of ancient art have been discovered in great numbers, chiefly in the sepulchres of ancient Italian cities. Their material is terra cotta, and they are painted with figures and scenes. The most beautiful, and indeed the most numerous, were formerly obtained from Campania and Magna Græcia; and it was much controverted among antiquarians whether the workmanship was not originally Greek. (Sir W. Gell, *Topography of Rome*, vol. i.) Of late years, the great sources have been the sepulchres of Etruria Proper. Five thousand have been taken in twenty-five years from the ruins of Tarquinii alone; and it seems to be now generally admitted that the manufacture is rightly called Etruscan; that it is of extreme antiquity; that in its progress Greek taste and style were introduced; and that the art had fallen into disuse in the flourishing period of the Roman empire. (Dennis, *Cities and Cemeteries of Etruria*; Mrs. H. Gray, *Sepulchres of Etruria*, p. 45.)

Vase-painting. Terra cotta vases are of two kinds generally—the black and the yellow; so distinguished from their painted decorations. In the black vases, which are the most ancient, the figures are covered with a black varnish, while the ground is left the colour of the clay; in the yellow, the figures, drawn in outline, are left the colour of the clay, while the ground is covered with the black varnish. The former are decorated with skiagrams (or silhouettes), the latter with monograms. Other varieties of vase-paintings exist, but they are exceedingly rare. [PAINTING.]

Vasodentine (Lat. vas, *a vessel*; dens, *a tooth*). In Anatomy, that modification of dentine in which capillary tracts of the primitive vascular pulp remain uncalcified, and carry red blood into the substance of the tissue. They form the so-called vascular or medullary canals, and are usually more or less parallel in their course. A large proportion of the central part of the tooth of the sloth and megatherium consists of vasodentine, and a smaller proportion of the same part of the tusks of the elephant and of the scalpriform incisors of the rodents.

Vassal (Fr.; Ital. vassallo, derived, according to Sir F. Palgrave *On the English Commonwealth*, from the Welsh gwâs, *a young man or page*; gwasâeth, *the state of pagehood*, being rendered in Latin vassaticum). The holder of a fief, by fealty and service, of a feudal superior or lord. [FEUDAL SYSTEM.] From the Celtic origin of this word, it has been inferred that some portion of the feudal usages were derived from those of the tribes which possessed Gaul and Britain before their annexation to the Roman empire. In the ancient documents of the Carolingian kings, the vassal is termed *vassus* or *homo fidelis*; the lord generally *senior*. The term *vassal* was also more generally used, in common language, to signify all who were dependent on a superior lord, from those who

held fiefs of him down to his serfs or villeins. (Guizot, *Civilisation en France*, vol. iv.)

Vastus (Lat.). A term applied by anatomists to two muscles of the thigh, the *external* and *internal vasti*.

Vateria (after Abraham Vater, a German botanical author). A genus of Indian trees of the order *Dipterocarpaceæ*. *V. indica* yields a useful gum-resin known as Indian Copal, Piney Varnish, White Dammer or Gumanine. The resin is procured by cutting a notch in the tree, so that the juice may flow out and become hardened by exposure to the air. It is employed in India as a varnish, and on the Malabar coast is used in the manufacture of candles, which burn with a clear light and an agreeable fragrance, and do not require snuffing. The Portuguese employ the resin instead of incense. Ornaments are fashioned from it under the name of *amber*. Medicinally it is employed in rheumatic and other affections. The timber is in request for building purposes.

Vatican. The palace of the popes, known by this name, stands on the right bank of the Tiber in Rome, and on the hill anciently called by the same name. Some say that it was begun by Pope Symmachus. It was inhabited by Charlemagne in 800; and the present irregular edifice has been raised by the gradual additions of a long series of pontiffs. (Milman's *Latin Christianity*, vol. iv. p. 452.) Its extent is enormous, the number of rooms, at the lowest computation, amounting to 4,422. Its marbles, bronzes, frescoes, statues, gems, and paintings, are unequalled in the world; and its library is the richest in Europe in manuscripts. The length of the museum of statues alone is computed to be a mile. Here are the Sistine Chapel; the Camere of Raphael, painted by himself and his pupils; the museum of Pius VI., peculiarly rich in objects of ancient Italian workmanship; and other deposits of art and antiquity, each of which by itself would suffice to render a city illustrious.

Vauban's Systems. [FORTIFICATION.]

Vaudeville. In French Poetry, a species of light song, frequently of a satirical turn, consisting of several couplets and a refrain or burden, introduced into theatrical pieces. The origin of the word is disputed; some derive it from Vau-de-Vire, a village in Normandy. Short comic pieces interspersed with such songs are also termed *vaudevilles*.

Vaudois. The inhabitants of some valleys of the Alps, lying in Piedmont between the Po and the Dora Riparia, whence they derive their name. They must be distinguished from the Waldenses, or followers of Peter Waldo, who acquired celebrity in the twelfth century, and from whom some writers have deduced both their religious tenets and their appellation also. (Milman, *Latin Christianity*, books viii. ix.) It has been asserted by some theologians that the true spirit of the primitive Christianity was kept alive among the Vaudois throughout the whole period of Romish corruption. This position, however, does not seem susceptible of proof. For three centuries they were viewed with displeasure by the dukes of Savoy and kings of Sardinia, their masters, and repeatedly visited with military execution, or more legal forms of violence. One great persecution, in the seventeenth century, is known to us by Milton's noble sonnet. Not long after it they were altogether expelled, and retreated into Switzerland, whence they returned by a celebrated march, and recovered their valleys by force; an event commemorated in the work of Arnaud, one of their pastors, *La Glorieuse Rentrée des Vaudois dans leurs Vallées*. Since 1848, however, they have been freed from all religious disabilities, and have spread beyond their original seat in the valleys of Luserna and St. Martin with the tributary branches. Vaudois churches have been established in some of the principal Italian cities. The language of the people is French, owing to their long connection with French and Swiss Protestants, which has caused that tongue to be used in their church service.

Vault (Fr. voûte, Ital. volta). In Architecture, an arched roof, so contrived that the stones, bricks, or other materials used in its construction, sustain and keep each other in their places. Vaults are circular and elliptical. When their section rises higher than a semicircle, they are said to be *surmounted*; when less, *surbased*.

Vauquelinite. The native chromate of copper and lead, composed (when pure) of 27·9 per cent. of chromic acid, 10·9 oxide of copper, and 61·2 oxide of lead. It occurs in small (generally macled) crystals, and in mammillated masses forming thin crusts, which are sometimes hollow and approaching to stalactitic. The colour is black (occasionally with a tinge of green or brown), and it is faintly translucent or opaque. It is chiefly found at Beresow in Siberia on Quartz; Pont Gibaud in Auvergne; at Congonhas do Campo in Brazil, and at the Sing-sing lead mine in New York. Named in honour of Vauquelin, the celebrated French chemist.

Vavassor (sometimes written *valvasor*, and *valvasour*, in old books). A word of uncertain derivation, but springing possibly from the same root with VASSAL). The vassals who held immediately of the higher nobility, under the feudal system in France, were frequently comprehended under this general name; the châtelains being such vavassors as possessed castles or fortified houses. (Hallam, *Middle Ages*, vol. i. p. 149.) The word, however, seems to have been of very loose application. Poor gentlemen are termed *vavassors* in old French romances. In England the title was not commonly used, although it is mentioned in Bracton in contradistinction to *baron*, and sometimes appears to have designated persons who held land by military tenure of others than the king. (*Archæologia*, vol. ii.)

Vector (Lat. *one who bears*). A directed line in space of definite length. [QUATERNIONS.] The more frequently occurring expression

radius vector has been already explained. [Co-ordinates; Radius Vector.]

Vectorial Angle. [Co-ordinates.]

Veda. The name given to the collective sacred literature of the Brahmans. The Vedas, more properly so called, are four in number: the Rig-Veda, the Yajur-Veda, the Sama-Veda, and the Atharva-Veda. These four works, each being a *sankita*, or collection, complete in itself, contain the substance or kernel of the Hindu faith, and round these has grown up a vast literature, which is also included under the general term *veda*, or knowledge. These four sanhitas are illustrated and commented upon in the Brahmanas, Suktas, Upanishads, Pratisakhyas, Vedangas, and in scholia of singular minuteness. This literature, which as a whole is now rarely mastered even by the Brahmans, is divided into two great classes, the Sruti, or literature of revelation, and the Smriti, or literature of tradition. This latter class contains the Sutras, or precepts which form the Vedangas or *members* of the Veda, these Vedangas, usually reckoned as six in number, being elaborate treatises on (1) Siksha, *pronunciation*; (2) Chandas, or *metre*; (3) Vyakarana, *grammar*; (5) Jyotisha, *astronomy*; (6) Kalpa, *ceremonial*. The contents of all these works are tabulated in systematic indices or Anukramanis, the most perfect of these still extant being that of the Rig-Veda, attributed to Katyayana; and called the Sarvanukrama, or universal index. The period assigned to this Sutra literature, by Professor Max Müller, extends from the second to the seventh century before the Christian era.

The periods preceding the Sutras comprise the literature of revelation. The first of these periods is that of the Brahmanas, which are subdivided into Karma Kanda, and Jnana Kanda (i.e. *practice* and *speculation*): the former term denoting the prayers, hymns, and formulæ to be recited at the sacrifice; the second, enquiries into the nature of man and of God, and the relations of matter and spirit. But, although the definition of the Brahmanas is too vague and comprehensive to constitute a special characteristic, there is evidence enough to show that they are the work of many persons, all striving to develope a system of Brahmanical Hinduism which is at best only faintly indicated in the earliest Vedic verses. The period assigned to this portion of Vedic literature by Professor Müller is only two centuries: by Prof. H. H. Wilson it is extended to the tenth or eleventh century B.C.

The period next preceding brings us to the Veda proper, the collection of hymns, prayers, formulæ, and ritual injunctions, known by the name of Mantra, and brought together in the Sanhitas or collections of the four Vedas. But of these the fourth is regarded by the Hindus themselves as of doubtful authority, and of the rest the Yajur-Veda and Sama-Veda are to be regarded as long posterior to the Rig-Veda, to which we must look for the most authentic and primitive representation of Hindu faith. This Rig-Veda is a collection of material compositions varying in date and authorship, some of which are to be recited at sacrifices, usually by priests termed *Hotri*, while others make not the slightest reference to any ceremonial or the existence of any sacerdotal order.

To this Mantra period Professor Max Müller adds one still earlier, the Chandas, i.e. the age in which the earliest songs were composed, and to which we must look for the germs of later Hindu theology and philosophy. It is in this period that the chief interest of Vedic literature centres for the western student. The songs of this age exhibit, in Professor Max Müller's words, 'the most ancient chapter in the history of the human intellect,' so that 'if this collection had been written but fifty years ago in some distant part of the world untouched by the general stream of civilisation, we should still call it more ancient than the Homeric poems, because it represents an earlier phase of human thought and feeling.' Hence the paramount value of these songs not only as indicating the belief of the earliest Hindu inhabitants of India on the nature of God, of law, of human duty and human destiny, but as exhibiting the germs out of which grew up the mythical systems of the eastern and western world. Without this literature the science of comparative mythology 'would have remained mere guess-work, without fixed principles and without a safe basis.' With it the refutation seems to be furnished of speculations which find in the mythical system of the Greeks a wilful perversion of doctrines clearly and distinctly revealed. 'Names which in Homer have become petrified and mythological are to be found in the Veda, as it were in a still fluid state. They next appear as appellations, not yet as proper names; they are organic, not yet broken and smoothed down.' The value of this collection is still further enhanced by the fact that even 'these earliest specimens of Vedic poetry belong, as has been said by Bunsen, to the modern history of the human race,' and thus a further light is thrown on the mode in which a knowledge of the conditions of human existence, and of their relation to the Unseen Maker and Preserver of all things, dawned upon the minds of men.

For further details, and for the bibliography of the subject, the reader is referred to Prof. Max Müller's *History of Sanskrit Literature*, and to Prof. H. H. Wilson, *Edin. Rev.* Oct. 1860.

Vedangas. [Veda.]

Vedanta. A sect among the Hindus, whose philosophy is professedly founded on the revelations contained in the Vedas. Their belief exhibits a close resemblance to the Quietism of European thinkers.

Vedette. [Vidette.]

Veer Out. In Naval Language, to give the ship more scope of cable. Also to let anything drop astern by a rope. *To veer* is also the old term for *to wear*.

Vegetable (Lat. vegetabilis, from vegetare, *to enliven*). One of the names of that division

or kingdom of animated nature which consists of plants. Thus the term *vegetable kingdom* is equivalent to *the kingdom of plants*. The properties, qualities, and substance of plants are distinguished from those of animals by the use of the term *vegetable*, as *vegetable juices*, *vegetable products*, &c.

In a more especial and colloquial sense, the term *vegetable* is used to indicate those particular plants which are used as esculents, these forming what is called *vegetable diet*. In this sense it includes the potato, cabbage, cauliflower, pea, bean, spinach, and such like, but does not embrace fruits properly so called, as the apple, pear, grape, &c., although these are included in its more extended sense, as embracing the whole vegetable kingdom. [BOTANY.]

Vegetable Earth. Soil in which decayed vegetable matter is in a much larger proportion than the primitive earths. In Horticulture, vegetable earth is called *mould*; and in Agriculture the term is applied to the surface soil of hollows, which contain alluvial soil beneath, and vegetable matter, generally of a black colour, on the surface.

Vegetable Flannel. A textile material largely manufactured in Germany from the *Pinus sylvestris*. A great number of persons are employed in the various processes of separating the fibre from the oil. The fibre, locally called *wold-wold*, is spun, knitted, and woven into various fabrics. It is said to be highly efficacious in restoring the function of the skin to its normal condition.

Vegetable Gold. An acid extracted from the roots of *Trixis Pipizahuac*.

Vegetable Hair. One of the names of the *Tillandsia usneoides*.

Vegetable Ivory. The albumen of the nut of *Phytelephas macrocarpa*.

Vegetable Marrow. The Succade Gourd, one of the many forms of *Cucurbita Pepo*.

Vegetable Parchment. The same as Papyrin, a substance resembling parchment, produced by immersing bibulous paper in dilute sulphuric acid. [PAPYRIN.]

Vegetable Sheep. A New Zealand name for *Raoulia eximia*, a composite plant growing on the mountain sides, where it forms woolly cushion-like masses resembling sheep.

Vegetable Silk. A cotton-like material obtained from the seed-pods of *Chorisia speciosa*.

Vegetable Tallow. A fatty substance obtained from *Stillingia sebifera*, *Vateria indica*, and other plants.

Vegetable Wax. A kind of wax obtained from the berries of several species of *Myrica*, especially *M. cerifera*. It is sometimes called *Myrtle Wax*, from the name of Candleberry Myrtle applied to *Myrica*.

Vegetal (Lat. vegetus, *lively*). In Physiology, this word is used to denote the class of vital phenomena common to plants and animals; viz. digestion and nutritive assimilation, growth, absorption, secretion, excretion, circulation, respiration, generation, as contradistinguished from a second class of vital phenomena, viz. sensation and volition, peculiar to animals: the first are called the *vegetal functions*, the second *the animal functions*; and the powers or forces on which they depend have been termed respectively the *vegetal life* and the *animal life*.

Vegetation. A general term designating plants as a group of organised beings distinguished from animals. [BOTANY.]

Vegetation, Chemistry of. From the moment when a seed begins to grow, a series of chemical changes are induced, essential to the developement of its germ. A general outline of the process has been given in art. GERMINATION.

Vehmic Courts (Ger. vehm or femgerichte). Criminal courts of justice, established in Germany during the middle ages. These courts are commonly said to have originated in those held by the Missi Dominici, or imperial legates, sent by Charlemagne into the provinces of his empire; but many circumstances point to their descent from the more ancient tribunals of the German tribes, held in the open air in the primitive periods of their history. (See a curious account of the free field courts of the Germans in Sir F. Palgrave's work on the *English Commonwealth*; Wigand's *Femgericht Westphalens*.) But the character under which these institutions became formidable and important, about the beginning of the thirteenth century, arose from the disordered state of Northern Germany, after the dissolution of the duchy of Saxony. The Vehmic, or, as they were called, free courts, were then modelled on a secret system of organisation. The president was usually a prince or count of the empire; his assistants (styled *Freischöffen*) were persons affiliated to the society by secret initiation, to the number, it is said, at one time of 100,000. All these were bound to attend the secret meetings of the courts when summoned, and to execute their decrees, if necessary, by taking the life of persons condemned. Westphalia, styled, in the language of the free courts, the *Red Land*, was the district in which their central authority was seated. These courts exercised a great power, which was occasionally serviceable in repressing the lawless violence of the nobles of that period, but which was also liable to be perverted to the gratification of private malice and tyranny. Thus, a Vehmic sentence decreed the death of Charles the Bold, duke of Burgundy. Various leagues were formed in the fifteenth century, by the nobles of the empire, for the purpose of destroying their influence: this was at last effected, chiefly by the introduction of a better system of public judicature and police in the several states.

Veil (Lat. velum). In Botany, a term used in describing fungi to denote the horizontal membrane connecting the margin of the pileus with the stipes.

Veins (Lat. venae). In Anatomy, elastic tubes which convey the blood from the arteries back to the HEART.

Veins, Mineral. [MINERAL VEINS.]

Velati. [ACCENSI.]

Velella (a word coined from the Lat. vela, *sails*). The name of a genus of Acalephes, characterised by a vertical crest or sail, by means of which they are wafted along the surface of the ocean.

Velites (Lat.). The light-armed infantry attached to a Roman legion were so called. (*Mém. de l'Acad. des Inscr.* vol. xxix.) They were equipped with bows, slings, and javelins, a light wooden buckler covered with leather and a head-piece.

Vellum (Fr. vélin, from Lat. vitulinus). A fine kind of parchment made of calfskin. The skins are limed, shaved, washed, and stretched in proper frames, where they are scraped with the currier's fleshing-tool, and ultimately rubbed down to a proper thickness with pumice-stone.

Veloce (Ital. *swift*). In Music, a term which, prefixed to a movement, indicates that it is to be performed in a rapid manner.

Velocipede (Lat. velox, *swift*, and pes, *a foot*). A vehicle invented at Mannheim in 1817, by M. Drais, consisting of a piece of wood about five feet long, and half a foot wide, resting on two wheels, one behind the other. On this a man sits, as on horseback, his feet touching the ground, and thus propelling the machine. The front wheel may be turned at pleasure, so that the rider may give any direction to the machine. Velocipedes are still sometimes seen: they are now usually made with four wheels, with a seat for the rider, who propels himself by the action of his feet on treddles connected with crank axles on the principle of the common foot lathe.

Velocities, Virtual. [VIRTUAL VELOCITY.]

Velocity (Lat. velocitas, from velox, *swift*). Velocity is measured by the space through which a moving body passes in a given time. The velocity of a body is uniform when it passes through equal spaces in equal times; and variable when the spaces passed through in equal times are unequal. It is accelerated when the force by which a body is put into a state of motion continues to act after the motion has commenced; and retarded when the moving body encounters obstacles which tend to destroy its motion. Velocity is merely a relative term; for there is nothing, as Biot remarks (*Traité de Physique*, l. iii. p. 148), which in itself is either swift or slow, any more than great or small. The velocity of an express train appears very great, yet it is slow in comparison with the motion of a point on the earth's equator carried round by the diurnal motion; and this, in its turn, is far inferior to the velocity of the earth in its orbit, which again is greatly exceeded by the velocity of light. For the velocity of falling bodies, see ACCELERATION; for the velocity of a body moving in a curve about a centre of force, see CENTRAL FORCES. [FINAL VELOCITY; GUNNERY; INITIAL VELOCITY; TERMINAL VELOCITY; VIRTUAL VELOCITY.]

Velocity, Angular. In Kinematics, angular velocity, in uniform motion around an axis, is measured by the ratio of the arc, described in every unit of time by any particle of the rotating body, to the distance of that particle from the axis of rotation. [ANGULAR MOTION.]

Velutinous (Ital. velluto, *velvet*). In Botany, a term applied to velvety surfaces, i.e. those having a hairy surface, which in texture resembles velvet, as in *Rochea coccinea*.

Velvet (Ital. velluto). A rich kind of stuff, used for dresses and for many other purposes. Of velvet there are properly only two kinds, that with a plain, and that with a tweeled, or, as it is also called, a Genoa ground or back. When the material is silk, it is called *velvet*; when cotton, *velveteen*. The latter is a species of *fustian*, which, under a variety of names, is largely used for men's wearing apparel.

Vena Cava. [HEART.]

Vena Portæ (Lat.). In Anatomy, the great trunk formed by the union of the veins from the abdominal organs of digestion, which trunk ramifies, after the manner of an artery, in the substance of the liver, and transmits its blood by capillaries to the hepatic veins.

Venation (Lat. vena, *a vein*). In Botany, the arrangement of veins or ribs in a leaf or other organ.

Veneer (Ger. furniren). In Architecture, a thin piece of material of a more valuable kind laid on another of a more common sort, by which the whole substance appears to be of the more valuable sort. Veneering is more usually applied to furniture than to strictly architectural purposes.

Venesection (Lat. vena, *a vein*, and seco, *I cut*). The opening of a vein with the lancet, as a means of withdrawing blood immediately from the general circulation.

Venetian School. In Painting. The distinguishing character of this school is colouring, and a consummate knowledge of chiaro-scuro. But it is not to be inferred that it is altogether wanting in still higher accomplishments: for the head of it was Titian; and in its ranks are to be found Tintoretto, Paul Veronese, Giorgione, the elder Palma, Lorenzo Lotto, and many other illustrious masters. The Venetian painters both of the *Quattrocento* period and of the *Cinquecento* were equally distinguished for their brilliant colouring, but a better understanding of chiaroscuro and the harmony of colouring has given a great superiority of effect to the works by the later masters. Of the Quattrocento painters may be mentioned especially John Bellini, Basaiti, and Cima da Conegliano. The higher effect of the later masters was accomplished in a great degree by skilful glazing—*velatura*, the veiling of one colour with another. [PAINTING.]

Venetian Talc. A kind of Talc or Steatite used for making the coloured crayons called *pastels*; and also the cosmetic called *fard*.

Veni, Sancte Spiritus (Lat. *Come, Holy Ghost*). The name given in the Roman

Church to a sequence in the office of the mass for Whit Sunday.

Venial Sin (Lat. venia, *forgiveness*). In Theology, venial sin is defined, by Roman Catholic theologians, to be a sin which weakens sanctifying grace, but does not take it away: it is not necessary, although commendable, to mention such sin in confession. Sins which take away sanctifying grace are termed *mortal*.

Venice White. A pigment consisting of carbonate of lead mixed with sulphate of baryta. *Dutch White* and *Hamburgh White* are similar mixtures.

Venire Facias (Lat. *cause to come*). In Law, a writ directing the sheriff to cause a jury to come and try a cause; now superseded by other forms of process. *Venire facias* is also the name given to the first process in an outlawry, in case of non-appearance to an indictment for misdemeanour.

Venose (Lat. venosus, *full of veins*). In Botany, a term applied to bodies having many branched veins, as in reticulated leaves.

Vent (Fr. vente). In Artillery, the hollow channel in a piece of ordnance through which the flame is communicated to the charge of powder for its ignition. All vents in the British service are two-ninths of an inch in diameter. [TUBE.]

Ventayle or Aventayle (Fr. ventail). The visor of a helmet. [HELMET.]

Venter (Lat.). In Entomology, the lower part of the abdomen.

Ventilation (Lat. ventilatio, from ventus, *wind*). This word signifies literally, *fanning* or *blowing*. In Domestic Economy, it is the art of conveying currents of fresh air through close apartments or confined places, so as to maintain the atmosphere in a state of purity.

Atmospheric air consists of three principal ingredients, nitrogen, oxygen, and carbonic acid, mixed together in the proportion by volume of four parts of nitrogen, one part of oxygen, and $\frac{1}{500}$ of carbonic acid. When the proportion of carbonic acid is increased to one per cent. air becomes unfit for respiration; and when the oxygen is withdrawn or consumed, it is rendered altogether incapable of supporting animal life or combustion. But there are operations both of nature and art continually going forward in which the oxygen of the atmosphere is consumed, and gaseous products evolved which are destructive of life. Thus, in the act of respiration, a certain portion of the oxygen contained in the air inhaled into the lungs is converted into carbonic acid, a substance which acts as a narcotic poison; and hence, in a confined apartment, air is soon rendered, by breathing alone, not merely incapable of maintaining life, but highly destructive of it, in consequence of the evolution of a deleterious gas. In like manner, oxygen is consumed, and carbonic acid evolved, in the process of combustion; and the burning of a pan of charcoal in a close room is a certain means of extinguishing life.

Although a decomposition and deterioration of air is thus continually going forward, nature has by various means provided so effectually for the restoration of the two constituent gases, that in whatever part of the world, and at whatever height in the atmosphere, air is taken, it is found when chemically examined to contain the three ingredients above mentioned, in almost exactly the same proportions. [AIR.]

Sources of Aërial Movement.—One of the most efficient means of ventilation is afforded by the action of heat. At ordinary temperatures, air suffers an expansion of about $\frac{1}{490}$ for each degree of Fahrenheit's thermometer, by which the temperature is raised; and being rendered specifically lighter in the same proportion, the pressure of the surrounding atmosphere predominates, and the heated air is forced upwards. This principle is exemplified in the action of the ordinary chimney, which may be regarded as a tube open at both ends, and placed in any position except the horizontal. The air in the lower end of the tube, being heated by the fire, rises and passes out at the upper end, while its place is supplied by the pressure of the fluid surrounding the lower opening; and the circumstances of motion are the same as if another tube, filled with air of the original temperature, were adapted to the lower end of the chimney, which is filled with heated air, so that the current is established in the same manner as in an inverted siphon, in which two columns of air of different densities, but equal altitudes, press against each other. At the lower opening of the chimney, the draught or velocity of the current is expressed by this formula,

$$v = \sqrt{[2gha(t'-t)]},$$

where v denotes the velocity in feet per second, g the accelerating force of gravity ($=32\cdot2$ feet per second), a the rate of expansion for one degree of increased temperature, t' the temperature of the heated air as it enters the chimney, and t that of the external air. It appears from this that the velocity of draught is as the square root of the height of the chimney, and the square root of the excess of temperature at the lower opening. But as the same quantity of air must be supposed to pass through every different section of the chimney in the same time, it follows that the velocity at every part must be inversely as the density, and therefore decreases from the bottom to the summit.

Warming the Air used for Ventilation.—In inhabited buildings of all kinds ventilation is necessary; but in some seasons warming is not necessary, and in tropical climates, instead of warming the entering air, expedients are sometimes employed to cool it. Nevertheless, the processes of warming and ventilating are so intimately associated that it will be expedient to consider them together.

Mr. Hood has found by his experiments that the water contained in an iron pipe 4 inches in internal diameter and $\frac{1}{4}$ inch thick, loses $\cdot321$ of a degree of heat per minute when its tempera-

ture is 125° in excess of that of the surrounding air; and as one cubic foot of water in losing 1° in temperature will heat 2,990 cubic feet of air 1° in temperature, a foot of 4-inch pipe will heat 222 cubic feet of air 1° per minute when the difference between the temperature of the air and of the pipe is 125°. One square foot of glass in a window will cool 1·279 cubic feet of air per minute as many degrees as the internal temperature of the room exceeds the external temperature. In conservatories, therefore, the quantity of air to be warmed per minute from the temperature of the external air to the temperature desired to be maintained is in round numbers 1¼ cubic foot, which gives a measure of the extent of heating surface required. The exact length of 4-inch piping necessary to heat such a structure may be determined by the following rule: Multiply 125 by the difference between the external and intended internal temperatures, and divide this product by the difference between the temperature of the pipes and the intended temperature of the apartment; finally, multiply this quotient by the number of cubic feet of air to be warmed per minute, and divide this product by 222, which will give the feet in length of 4-inch pipe necessary to produce the desired result. Thus, in a hothouse in which it is required to maintain a temperature of 75°, the external air being sometimes as low as 10°, if the cooling surface of glass be 800 square feet, then the refrigeration will be such as would cool 1,000 cubic feet of air per minute from 75° to 10°, and this refrigeration will require 292 feet of 4-inch pipe to counteract it. About 4 square feet of heating surface in a boiler exposed to the direct action of a pretty strong fire will evaporate a cubic foot of water in the hour, and will supply the heat required by 232 feet of 4-inch pipe which is required to be kept at a temperature of 140° above that of the surrounding air.

In warming apartments by steam of 212° the temperature of the pipes does not exceed 200°. But the most usual method of warming is by hot water, sometimes carried in cast-iron pipes with faucet joints, and sometimes in wrought-iron pipes, like gas pipes, with screwed joints. Cast-iron pipes, while they are being heated from 32° to 212°, expand $\frac{1}{900}$ of their length. For heating mills by steam, a pipe is usually led into every floor with a siphon pipe at the end for conducting away the condensed steam, and these pipes are set with a small declivity to cause the water to run towards the siphon at the end. This siphon is sometimes replaced by a valve so constructed as to allow of the escape of the condensed water, but to prevent that of the steam. In heating by hot water, the rapidity of the circulation will depend upon the height to which the circulating pipes rise above the boiler, and the difference in the temperature of the ascending and descending columns. Thus, if the average temperature of the pipes be 170°, the difference in the temperatures of the ascending and descending columns be 8°, and the height of the columns be 10 feet, then with the columns nearly filled the hotter will stand ·331 inch higher than the cooler, in order that the two may balance from the diminished specific gravity of the hot column; and this difference of height will give a circulating velocity of 79 feet per minute. If the height of the columns be reduced to 5 feet, the circulating velocity will become 55 feet per minute. The boiler by which the water is heated may either be an open or a close one; and the pipes may either be a closed circuit with a coil immersed in the boiler for acquiring heat, and a coil exposed to the air for imparting heat, or the refrigerating coil may project the returning pipe to the bottom of the boiler, and the transmitting pipe may rise from a point a little below the water level. A moderately sized house may thus be very effectually heated by the aid of a common washhouse boiler open at the top, or fitted only with a wooden lid. The boiler being nearly filled with water, a pipe is to be led from a point a few inches below the water surface, and coiled either at some point near the foot of the stairs, or in some other convenient situation where the air will gain ready access to it, and after being heated may ascend through the house. The descending end of the coil is then to be carried to the bottom of the boiler, and a small pump is to be applied at the highest part of the coil, to pump the coil full of water. The fire then being lighted, and the water level in the boiler, maintained by adding more water to the boiler to supply the place of that which is sucked into the pipes, the circulation will begin and will continue so long as the boiler is kept hot. But every morning when the fire is lighted, it will usually be necessary to pump out of the coil the air liberated from the water, which, however, it will only take a minute or two to do.

In discussing the proper means of ventilating houses and public buildings, there are three main points which present themselves for consideration: (1) the quantity of air necessary to be introduced; (2) the proper mode of its introduction; and (3) the arrangement by which the ventilating current may best be maintained. Peclet is of opinion that 5 cubic feet of air per minute should be introduced into a house or building for each occupant of it, whereas Reid maintains 10 cubic feet per minute to be the right quantity, and Arnot 20 cubic feet. Roscoe concludes from his examination of the air of soldiers' barracks that 20 cubic feet of air per minute are required for ventilation; and Morin found that in the theatre of the Conservatoire at Paris the amount needed was about 18 cubic feet of air per head per minute, which is also about the allowance in most of the Parisian theatres. In hospitals about twice this quantity is necessary. In good dwelling-houses, however, with lofty rooms and few occupants, 3½ cubic feet of air per minute for each person will be sufficient. A common window will allow about 8 cubic feet of air per minute to pass, and if an apartment be heated

with pipes maintained at a temperature of 200°, then, with a temperature of 10° below freezing outside, to maintain a temperature of 60° within there must be 1 square foot of pipe surface for every 6 square feet of window surface, or 120 square feet of wall, or 6 cubic feet of air per minute escaping as ventilation. A double window only lets through one-fourth of the heat that is let through by a single one; and in cold weather it will be useful to keep the blinds down, as the transmission of the heat will thus be diminished.

With regard to the proper mode of introducing air into apartments for ventilation, Morin is of opinion that in summer it should be introduced in thin sheets or threads near the ceiling, whence it would subside, and, dragging the impure air with it by friction, should be discharged through outlets nearer the floor. In common houses this may be done by opening the window a little at the top. But in barracks and other crowded buildings it is best done by means of perforations or air bricks in the walls, communicating with a triangular box or cornice running along the wall near the ceiling, with the upper inclined side covered with perforated zinc for permitting the air to flow obliquely upward against the ceiling, while the lower inclined side is formed of board without perforations. A foul-air shaft is usually carried up in the form of a chimney or funnel, proceeding from the ceiling to a height of a few feet, and terminating in inverted louvres to prevent down draughts in gusty weather. About one square inch of inlet for every 60 cubic feet of capacity of the room is the usual proportion in barracks, and one square inch of outlet in the foul-air shaft for every 60 cubic feet of space in the lower floors, or for every 55 cubic feet in the floor next above, or for every 50 cubic feet in the top floor. Besides an open fireplace to heat the rooms in winter, an inlet is provided for the admission of air behind the grate, where it is heated and escapes through an air-flue, which conducts it to an orifice near the ceiling where it is delivered into the room. In large rooms, whether barracks or hospitals, it is advisable to have many foul-air flues, or openings into a horizontal foul-air flue running through the length of the apartment, so as to collect the foul air at the spot where it is generated, and not to permit it to be all swept to one end of the room, but so to govern the eduction that all parts of the room will be pure alike. The entering air should be conducted through a small bent flue, which springs from the lower surface of the arch which covers the window and conducts to the perforated cornice already described. A considerable portion of the heat lost by transmission through the window in cold weather will thus be recovered by being communicated to the entering air. All private houses ought to have perforations in the walls which will admit air to the space behind the grate, which air, after being heated by contact with the hot iron, should be permitted to enter the room either through perforations in the upper part of the front plate of the grate, or through a hot-air flue provided for the purpose. Wherever mixing chambers can be provided for diffusing the hot among the cold air, before entering the room, such mixing will be advisable. But in other cases it will suffice to deliver both streams of air near the ceiling, where they will mix before descending to the lower part of the room. The foul-air shaft should proceed from that part of the room which is farthest removed from the inlet orifices, and its debouch should in all cases be so far removed from the points at which the air enters, as to give proper assurance that no part of the foul air will come into the room again.

The most pleasant, convenient, and economical mode of warming a dwelling-house consists in providing for the admission of the external air into the hall, where a close stove (not an open fireplace) raises its temperature to about 55° Fahr. Very moderate fires in the separate apartments will then secure sufficient warmth and thorough ventilation, if such apartments be made to derive their supply of air from the hall by means of ventilating grids near the ceiling.

One of the most necessary and neglected applications of ventilation is to the case of ships and steam vessels in tropical climates. In steam vessels the neglect of such ventilation is specially inexcusable, as it could be so easily accomplished by the aid of the furnaces. In ordinary furnaces about 300 cubic feet of air pass through the fire for every pound of coal burnt; in a steamer, therefore, of 500 nominal horse-power, working to five times the nominal or 2,500 actual horse-power, if we take the consumption of coal to be 2½ lbs. per actual horse-power there will be 6,250 lbs. of coal burnt every hour, or 104 lbs. every minute, which will require 31,200 cubic feet of air per minute. This exhausting power, by causing the furnaces to draw their air from the cabins, will afford ventilation for 624 persons at 50 cubic feet of air per head per minute—an allowance which would not be too great, considering that it is not ventilation alone, but refrigeration also, that is wanted in such a case.

Ventilator. Any machine or contrivance for promoting or regulating ventilation. The common ventilators placed in windows or in external walls serve only to retard in some degree the entrance of the current, to disperse it in different directions, and to prevent any sudden increase in the intensity of the draught. They have no power of acting so as to create a current, or keep up its intensity when it has been established, and are, as a rule, of little use.

Ventral (Lat. ventralis, from venter, *the belly*). In Anatomy, the parts or the aspect of the region of the belly: the plates of the vertebral or serous layer of the embryo that are extended towards that region are called the *ventral laminæ*.

VENTRAL. In Botany, a term used to signify that the part to which it is applied belongs to the anterior surface. Thus, a ventral suture is

the line running down the front of a carpel on the side next the axis.

Ventricle (Lat. ventriculus, dim. of venter). A term in Anatomy, applied to cavities of the brain and of the heart.

Ventricose. In Botany, a term applied to those organs which swell unequally on one side, as the corolla of many labiate and personate plants.

VENTRICOSE. In Zoology, a part is so termed when it bellies out as if filled with air.

Ventriloquist (Lat. venter, and loquor, *I speak*). One whose voice appears to come from his belly. Ventriloquists are generally supposed to have the power of making the voice appear to come from distant objects or quarters; but this is a deception, arising out of the manner in which the ventriloquist manages his voice. The art appears to consist in filling the lungs with air, and employing, during expiration, such organs of voice as can be used without the aid of the lips, or at least with as little movement of the lips, mouth, or cheeks, as is compatible with the pronunciation of certain words.

Venue (Nor. Fr. visne; Lat. vicinia, *neighbourhood*). In Law. By the original institution of trial by jury, jurors were summoned from the immediate neighbourhood where a fact happened, to try it by their own knowledge. Hence, long after the institution had been altered in character, jurors were still summoned in point of form from the parish, village, &c., until, by 4 Anne c. 16, they became summonable, as they still are, from the body of the county. The venue, therefore, was the neighbourhood named in the VENIRE FACIAS, or writ summoning the jury. In civil actions the venue is the county in which the action is to be tried, which is specified in all material allegations in the pleadings; it need not be the county in which the fact took place, except in what are called *local actions*. [PLEADING.] It can be *changed*, i.e. the trial may be directed to take place in another county, either by consent of parties, or by special order of the court or a judge, on the ground of material evidence, apprehended unfairness of trial, and the like. In criminal proceedings, the general rule is that the offence must on the face of the indictment appear to have been committed within the jurisdiction of the court before whom the prisoner is tried, but many modifications of this rule have been introduced by various statutes. (See particularly 14 & 15 Vict. c. 100.)

Venus (Lat.). In Astronomy, one of the principal planets, the second in order of distance from the sun, and the most brilliant of all the planetary bodies. From her alternate appearance in the morning and evening, Venus was called by the Greeks *Hesperus* and *Phosphorus*, the *evening* and *morning star*; sometimes also she is called the *shepherd's star*.

The mean distance of Venus from the sun is ·7233316, that of the earth being unity; her true distance is found by multiplying the old and new values of the earth's distance from the sun, viz. 95,274,000 and 91,678,000 miles, by this number. Her sidereal revolution is performed in 224·7007869 mean solar days; and her synodical period, or the interval between her successive conjunctions with the sun, is 583·920 mean solar days. The inclination of the orbit to the ecliptic was 3° 23′ 28·6″ at the commencement of the present century, and is subject to a decrease of about 0·0455″ in a year. The eccentricity of the orbit is ·00685900, half the major axis being unity; and the longitude of the ascending node at the commencement of the present century was 74° 54′ 12·9″, having a motion westward, when referred to the fixed stars, amounting to 17·6″ in a year.

The mean apparent diameter of Venus, or her apparent diameter when at her mean distance, is 16·9″; but it is subject to great variations, being only 9·5″ at the time of her superior conjunction, and at the time of the inferior conjunction sometimes so much as 62·0″. Comparing this with her mean distance, her true diameter is ·975, that of the earth being unity; and is consequently about 7,800 English miles. Her volume is therefore ·996 that of the earth. Her mass is $\frac{1}{401911}$ that of the sun.

Venus, being an inferior planet, is never seen in opposition to the sun. Her greatest elongation, or angular distance from the sun, varies from 45° to 47° 12′. According to her various positions relatively to the sun and earth, she changes her phases like the moon, appearing when she first emerges from the sun's rays and becomes visible in the morning as a fine luminous crescent, the horns of which are turned away from the sun. As the planet recedes from the sun, the breadth of the crescent increases: at the greatest elongation it becomes a semicircle; after this the breadth of the disc goes on increasing till the planet arrives at its superior conjunction, where it appears as a full orb, the illuminated side being turned towards the earth. These appearances, on account of irradiation, are not appreciable by the naked eye, but they become visible in an ordinary telescope.

Venus is supposed to revolve about an axis; and the time of rotation is stated, from observations made by Schroeter, to be 23 h. 21 m. 7·2 s., the axis of rotation being inclined to the ecliptic in an angle of about 75°. There is, however, considerable doubt as to the accuracy of these conclusions. On this subject Sir John Herschel remarks, that Venus, 'although it attains occasionally the considerable apparent diameter of 61″, which is larger than that of any other planet, is yet the most difficult of them all to define with telescopes. The intense lustre of its illuminated part dazzles the sight, and exaggerates every imperfection of the telescope; yet we see clearly that its surface is not mottled over with permanent spots like the moon: we perceive in it neither mountains nor shadows, but a uniform brightness, in which we may, indeed, fancy obscurer portions, but can seldom or

never rest fully satisfied of the fact. It is from some observations of this kind that both Venus and Mercury have been concluded to revolve on their axes in about the same time as the earth. The most natural conclusion, from the very rare appearance and want of permanence in the spots, is, that we do not see, as in the moon, the real surface of these planets, but only their atmospheres, much loaded with clouds, and which may serve to mitigate the otherwise intense glare of their sunshine.' (*Outlines of Astronomy*, p. 311.)

Venus is sometimes seen to pass over the disc of the sun, presenting a phenomenon analogous to that of a solar eclipse by the moon. This phenomenon, which is called a *transit of Venus*, can only happen when the planet is at its inferior conjunction, and, at the same time, very near one of its nodes. It is therefore a rare occurrence, but a very important one, inasmuch as it affords the best means astronomers possess of determining the sun's parallax, and consequently the dimensions of the planetary system. [PLANET.] Delambre has given a list of all the transits occurring in a period of 2,000 years. The following contains all that have happened since 1631, and that will happen before the end of the twenty-first century:—

1631, Dec. 6.	1874, Dec. 8.
1639, Dec. 4.	1882, Dec. 6.
1761, June 5.	2004, June 7.
1769, June 3.	2012, June 5.

The first transit ever seen was that of 1639, which was observed in this country by Horrox and Crabtree. The importance of the phenomenon for determining the sun's parallax was first pointed out by James Gregory in his *Optica Promota*, 1663.

VENUS. In Mythology. The name of this Latin deity is, perhaps not without reason, connected with the Sanscrit root *van*, to desire, love, or favour. Thus, in the Rig-Veda, girvanas means *loving invocations*, and yajnavanas *loving sacrifices*, and the common Sanscrit preserves *vanita* in the sense of a beloved woman. To the same root belong apparently the Anglo-Saxon *wynn*, pleasure, the German *wonne*, and the English *winsome*. The word Venus, therefore, denotes either love or favour; to the former signification belongs the Latin venustas, to the latter the verb veneror, to venerate, i.e. to seek the favour of anyone, *venia* being strictly favour or permission. Venus was probably not the oldest, and certainly not the only name, for the goddess of love in Italy, as the Oscan deity was named Herentas; but Venus herself remained little more than a name, until she was identified with the Greek APHRODITE. She is not mentioned in any of the traditions relating to the regal or early republican periods, and the festival of the Vinalia had nothing to do with her name. But when the Roman MARS was confused with the Greek Ares, the myth of the loves of Ares and Aphrodite was imported into the notion of Venus, while fresh additions were made on the strength of the Homeric hymn which described Æneas (the ancestor of Romulus, the founder of the Roman state), as a son of Anchises and Aphrodite. Her worship being once introduced, it was rapidly multiplied under that profusion of epithets which characterises the religious system of the Romans generally. Thus we find a Venus Murtea or Murcia, a name of doubtful origin; Venus Cloacina, from cluere, Gr. κλύζειν, *to wash or purify*; Venus militaris, barbata, equestris, as well as other epithets.

The introduction of Venus into the story of PSYCHE by Appuleius is a subject of greater interest for the student of comparative mythology. It has been commonly supposed that in this tale Appuleius, deriving the materials simply from his own imagination, intended to set forth allegorically the trials and sufferings of the human soul in its search after happiness and wisdom, the moral of the story agreeing with that of the well-known apologue of Prodicus, entitled the *Choice of Heracles*. An analysis of the tale will, however, show that Appuleius found all his materials made ready to his hand, and that he has rather weakened than strengthened the beauty of the myth by adapting it to the taste of a thoroughly artificial age. The story is, in short, one of the few which point to the existence of popular fairy tales during the so-called classical periods; and the incidents in the tale of Psyche are precisely those of that large class of legends of which the popular story of *Beauty and the Beast* may be taken as a typical example.

These tales are found scattered through almost the whole of the Aryan family of nations; many of them have only recently been set down in writing, and others perhaps exist still only in oral tradition. They vary, of course, in local colouring, as well as in the names employed; but the sequence of incidents is for the most part the same, and the leading ideas, as well as the turning points in the tale, are the same in all, without exception. In each case the youngest and most beautiful of three daughters is married or given up to some unsightly being or monster, or to some one whom she is led to suppose hideous and repulsive. In some instances the enchantment is ended when the human maiden feels and confesses her love for the disguised being in his unsightly shape: in the more common version, which Appuleius followed, the maiden has a lover who is marvellously beautiful, but whose beauty she has never seen. In all cases, however, there are jealous sisters or a jealous mother who insist that the lover is hideous, and incite her to look upon him while he is asleep. Following their advice, she disregards the warnings in each case given that such curiosity cannot be indulged without causing grievous disaster and distress. In each case the sleeping lover is awakened by a drop of oil or tallow from the torch or candle

in the maiden's hand, and is instantly transformed, generally into a bird who tells her that she must wander in search of him through many weary years, and do the bidding of some harsh mistress into whose power her fatal curiosity has brought her. In some versions, as in that of Appuleius, this mistress is the mother of the lost lover. Then follow the years of wandering and toil, which can be brought to an end only by the achievement of tasks, generally three in number, and all utterly beyond human powers. In these tasks the maiden is aided by brute creatures whom she has befriended in their moment of need, and who perform for her that which she could not possibly accomplish herself. The completion of the ordeal is followed by the happy union of the maiden with her lost lover.

No hypothesis of conscious or unconscious borrowing can account for the diffusion of this myth in Italy, Egypt, India, Norway, and Germany, among classes who have never possessed a written literature, and in countries between which there was in earlier times no intercommunication. The uselessness of any such hypothesis has been shown by Mr. Dasent in the Introduction to the *Popular Tales from the Norse*; but the internal evidence of the stories will probably render all other arguments superfluous for those who will take the trouble to compare them. The extent to which the myth, retaining still the essential idea, may become modified, is seen in the tale of 'The Soaring Lark' in Grimm's *Household Stories* (*Kinder- und Haus-Mährchen*). In this story the maiden knows that the being who is during the day a lion is at night a man, but no ray of light must fall upon him while he is in his human shape. At her entreaty, however, he goes to the bridal feast of her elder sister, where a single ray of light streams in upon him through a chink in a door made of unseasoned wood, and the maiden entering the room finds a dove, who says that for seven years he must fly about in the world, but that at every seventh mile he will let fall a drop of blood and a feather to guide her in her quest of him. At last this guidance fails her, and she asks the sun and moon to tell her whither the dove has gone. As in the tale of Demeter and PERSEPHONE, they are unable to tell her, but they give her a casket and an egg which one day may be of use. She then asks aid of the north wind, who bears her over the world until she rescues her lover (who has resumed his lion's shape) from a caterpillar who is an enchanted princess. But the latter, when disenchanted, seizes on the maiden's lover and bears him away. The maiden follows to the place where she hears that the wedding is to be celebrated, and then opening the casket finds a dress which glistens like the sun, and which the princess seeks to buy. But it can be given only for flesh and blood, and the maiden demands access to the bridal chamber as her recompense. During the first night her lover sleeps by force of a potion, but her voice sounds in his ears like the murmuring of the wind through the fir-trees. On the next day, learning the trick, he refuses the draught; and the maiden, availing herself of the gift bestowed by the moon, is reunited to him at last.

A closer parallel to the story of Psyche is furnished by the beautiful tale, entitled 'East o' the Sun and West o' the Moon,' in the *Popular Tales from the Norse*; and with these may be compared the tales of the 'Two Brothers,' the 'White Snake,' the 'Wood-cutter's Daughter,' the 'Water of Life,' and others, in Grimm's collection of *Household Stories*, and more especially the story of Tulisa, a tale obtained from a washerwoman at Benares, and published in the *Asiatic Journal*. This tale is, in Professor Benfey's opinion, very ancient. See also the tales in the *Pentameron* of Basil, 15, 19, 44, and Hahn's *Greek and Albanian Tales*. For a more complete analysis of the fable of Appuleius, the reader is referred to Friedläuter's *Sittengeschichte Roms*.

VENUS. In Zoology, a name applied by Linnæus to a genus of *Vermes Testacea*, including those which have a bivalve shell with the frontal margin flattened, with incumbent lips; the hinge with three teeth, all of them approximate, and the lateral ones divergent at the top.

The Bivalves thus characterised enter into the Cardiacean family of the Testaceous Acephala of Cuvier, and are subdivided into the genera *Venus* proper, Lam.; *Astarte*, Sowerby; *Cytherea*, Lam.; *Capsa*, Brug.; *Petricola*, Lam.

Venus' Bath. In Botany, *Dipsacus sylvestris*: so named from water collecting in the connate bases of the opposite leaves.

Venus' Hair-stone. A name given to the clear rock crystal, containing hair-like filaments or long acicular crystals of titanium, which is found in Madagascar, Brazil, &c.

Venus' or Cupid's Pencils. Violet Quartz enclosing small golden-brown fibres of oxide of iron, found at Bristol and other localities.

Venus Urania. A Latin adaptation of the Greek Aphrodite Urania, who was thus distinguished from Aphrodite Pandemos. For the history of the name Urania, see URANUS.

Verandah. A term of Eastern origin, applied to a light gallery external to a house, supported on pillars, and frequently enclosed in front with lattice-work.

Veratria or **Veratrine.** An alkaline principle found in the root of the *Veratrum album*, or white hellebore, and in the seeds of the *Asagræa officinalis*. It is acrid and poisonous; not easily soluble in water, readily soluble in alcohol, and less so in ether. It excites violent sneezing. It is used externally in the form of ointment, to allay the pain of neuralgia. It is represented, according to Merck, by the formula $C_{64}H_{52}N_2O_{16}$. [COLCHICUM.]

Veratric Acid. An acid contained in the seeds of *Asagræa officinalis*, formerly known

as *Veratrum Sabadilla*, hence also called *sabadillic acid*. Its formula is $C_{18}H_{10}O_8$.

Veratrum (Lat.). A genus of *Melanthaceæ*, consisting of perennial herbs, natives of the mountainous regions of Europe and North America, and having erect stalks, ovate pointed leaves, and panicles of polygamous flowers. These plants are remarkable for their acrid properties. The rootstocks of *V. album*, called White Hellebore, are collected in the Alps and Pyrenees for medicinal purposes. They are so extremely acrid that the drug is rarely employed in this country. Its effects seem to be due to the presence of *veratria*, an acrid alkaline substance found also in *Asagræa*. Gardeners make use of *V. album*, in the form of powder, to destroy caterpillars. *V. viride*, a North American species, is used for similar purposes, but seems rather less powerful. Although containing so powerful a poison, slugs and snails are particularly fond of the leaves of these plants.

Verb (Lat. verbum, *a word*). In Grammar, a part of speech which consists of an affirmation and a property or attribute affirmed. Verbs are distinguished into *transitive*, *intransitive*, and *passive*. Besides these, there is the *verb substantive*, which expresses simple affirmation abstracted from any particular property affirmed. [GRAMMAR.]

Verbascum. The Mullein genus is distinguished from its congeners in the order *Scrophulariaceæ*. It is widely dispersed over Europe, Western and Central Asia, and Northern Africa, and an immense number of species have been described, many of them probably mere varieties or hybrids. They are tall erect strong-growing mostly biennial herbs. The thick woolly leaves of *V. Thapsus*, the Great Mullein, have a mucilaginous bitterish taste, and a decoction of them is employed in domestic practice in catarrhs and diarrhœa. They are also used as emollient applications to hard tumours, and in pulmonary complaints in cattle—hence one of its popular names is Bullock's Lungwort. The ancient Greeks are said to have used the leaves as lamp-wicks, while the Romans, who called the plant *candelaria*, dipped its stalks in suet to burn at funerals. The English name, Hig-taper or High-taper, appears to allude to a similar use. This was a famous plant with the witches of old, whence it has been sometimes called *Hag-taper*.

Verbenaceæ (Verbena, one of the genera). A natural order of perigynous Exogens, consisting of trees, shrubs, or herbs, closely resembling *Labiatæ* in their tubular or campanulate calyx, in their corolla which is usually irregularly five-lobed, and in their two or four ovules enclosed in as many cells, but differing in the ovary not being lobed, and having a terminal style. They also rarely have the aromatic properties of *Labiatæ*. The species are numerous, the greater number tropical or from the temperate regions of the southern hemisphere, very few being found in Europe, Northern Asia, or North America. The typical genus, *Verbena*, furnishes one of the most beautiful and popular of our garden flowers. The remarkable virtues which the common Vervain, *Verbena officinalis*, was reputed to possess, are apparently imaginary, though Vervain has ever been held to be 'an herb of grace,' and so highly was it esteemed that people are said to have worn it about the person. Before it was gathered for this purpose, the herb was first crossed and then blessed in the words—

> 'Hallowed be thou, Vervein,
> As thou growest on the ground,' &c.

The *Aloysia citriodora* is the Lemon-scented Verbena of the gardens. The Verbena of the perfumers, so much prized for its lemon-like scent, is the lemon-grass, *Andropogon Schœnanthus*, from which the *oil of verbena* is extracted.

Verbesina (altered from Verbena). A rather extensive American genus of *Compositæ*. The Ramtil-oil plant of India was formerly referred to this genus, and is frequently found mentioned under the name *V. sativa* in modern books, though long ago separated under the name of *Guizotia oleifera*. The Mexicans use a decoction of the Capitaneja (*V. Capitaneja*) as a vulnerary, applying it to the sores caused by the saddle on the backs of horses and mules.

Verbium. A very rare metal occurring with yttrium and erbium in the minerals orthite and gadolinite.

Verdict (Lat. verum dictum). In Law, the answer of a jury given to the court concerning the matter of fact in any cause committed to their trial. A *special verdict* is a verdict not delivered generally in favour of either plaintiff or defendant, but finding and stating the facts, and referring the law arising upon them to the judgment of the court. [JURY.]

Verdigris (from Fr. verd, and gris). A blue-green pigment, originally prepared in the South of France by covering copper plates with the refuse of the grape after the expression of the juice for wine. It appears to be a mixture of the subacetates of copper, and is now largely manufactured in this country by alternating copper plates and pieces of coarse woollen cloth previously soaked in crude pyroligneous acid.

Verditer. A blue pigment, generally prepared by decomposing solution of nitrate of copper by the addition of chalk. It is a hydrated carbonate of copper.

Verdurer or **Verderor.** An officer in the royal forests, whose peculiar charge was the care of the *vert*, i.e. in forest language, the trees and underwood of the forest, all vegetation sufficient to cover a deer being included in the term, which was divided in old language into *over vert* and *nether vert*. The office of verdurer still subsists in some of the royal forests. By stat. 10 Geo. IV. c. 50 s. 100, the verdurers were to enquire into enclosures and encroachments, and impose fines on the of-

fenders; but their jurisdiction is now practically obsolete.

Verge of the Court. The compass of the queen's court, within which is bounded the jurisdiction of the lord steward of the household. It is said to be so called from the verge, or rod of office, borne by the marshal. [STEWARD.]

Vergers (Fr. verge; Lat. virga, *a rod*). Officers attached to cathedrals and collegiate churches, whose duty it is to preserve order, &c.; their name is derived from their carrying a small mace or rod tipped with silver before the clergy.

Vergette (Fr.). In Heraldry, a pallet, or small pale. A shield divided by pallets is termed *vergette*.

Verjuice (Fr. verjus). The expressed juice of unripe or green grapes. The term is applied also to a kind of vinegar made from the juice of unripe apples.

Vermeil or **Vermeille.** A jeweller's name for crimson Garnet, with a slight orange tinge. [PYROPE.]

Vermicelli (Ital.). A paste of wheat flour in the form of wormlike cylinders of various diameters; the smallest or thread-like being termed *vermicelli*, and the larger *macaroni*. It is also cut into ribands and other forms, and is then called *Italian paste*. It is made by forcing the paste through small apertures in an iron plate, which is done by a powerful screw press. The most glutinous varieties of wheat are those which yield the fittest flour for this manufacture.

Vermiculite (Lat. vermes, *a worm*). A fine scaly variety of Pyrosclerite, resembling Talc in appearance, and composed of micaceous plates cemented together by a whitish matter; it is a hydrated bisilicate of magnesia, protoxide of iron, and alumina. When heated to redness it divides, with a vermicular motion, into threads, as if it were a mass of small worms: hence the name. It is found in North America, in Vermont, and at Milbury, Massachusetts.

Vermiform (Lat. vermis, and forma, *shape*). In Anatomy, certain parts that are convoluted and shaped like a worm are so called, as e.g. a hollow process or prolongation of the intestinum cæcum; a part along the middle of the upper and under surfaces of the cerebellum.

Vermifuges (Lat. vermis, *a worm*, and fugo, *I put to flight*). Medicines used in effecting the expulsion of intestinal worms. [ANTHELMINTICS.]

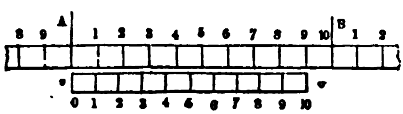
Vermilion (Fr. vermeil, Ital. vermiglione). Red sulphide of mercury. [CINNABAR; MERCURY.]

Vermin (from Lat. vermis). Quadrupeds, reptiles, worms, or insects, which are injurious to the cultivator. The number of these is great in every country, and calls into continual requisition the skill and vigilance of man to subdue them. In British agriculture the sheep and poultry are attacked by foxes, weasels, and other quadrupeds; the corn and other seeds and roots by rats and mice; and all plants, as well as seeds, by the weevil, the gnat, the turnip-fly, the Hessian-fly, the cockchafer, the wire-worm, and other insects. In gardening, almost all plants are liable to the attacks of insects, seeds to those of rats and mice, and fruits to be eaten by birds. In general, the most efficient mode to subdue insects which attack plants is to invigorate their growth as much as possible by culture, because it is found that insects thrive best on plants which are in a state of incipient disease; and the next best mode to this, is the encouragement of such natural enemies to vermin as are not themselves more injurious than the creatures they prey upon. There are some insects, such as the turnip-fly, the wheat or Hessian fly, and the aphis or green fly, which multiply very rapidly owing to the extensive propagation of the plants on which they feed; and these are the insects which are most injurious to the cultivator, because he cannot multiply their natural enemies in the same proportion as he multiplies the insects by cultivating on a large scale the plants on which they grow. The aphis he may destroy by the application of tobacco-water and other means; but he has little or no control over the turnip-fly or the wheat-fly. Happily for man, the seasons are not always alike propitious to these and other enemies to vegetation.

Vermontite. [MISPICKEL.]

Vernation (Lat. vernus, *belonging to the spring*). In Botany, the manner in which leaves are arranged within the leaf-bud.

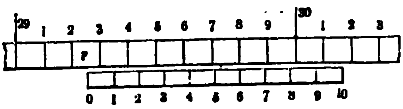
Vernier. A contrivance for measuring intervals between the divisions of graduated scales or circular instruments. The name is given from that of the inventor, Peter Vernier, who published an account of the contrivance in a work printed at Brussels in 1631. It consists of a small movable scale, sliding along the graduated scale or arc; the divisions on the one scale being to those on the other in the proportion of two numbers which differ from each other by unity. The theory of the instrument, and the manner in which it is used, may be explained as follows: Let AB $=a$ be



a distance on the scale containing n of its divisions. Let $v\,v$ be another scale equal in length to $n-1$ of the divisions on A B; and let $v\,v$ be divided into n equal parts. Since the distance AB $=a$, and contains n equal parts, each division on the scale $=\frac{a}{n}$. Hence the length of the vernier $vv=a-\frac{a}{n}$; and, as it is also divided into n equal parts, each division on the vernier $=\frac{1}{n}\left(a-\frac{a}{n}\right)=\frac{a}{n}-\frac{a}{n^2}$; and therefore the

difference between a division on the scale and one on the vernier $=\frac{a}{n^2}$. Suppose the zero of the vernier to coincide with the division marked A on the scale; then the first division on the vernier will not coincide with the first after A on the scale, but fall behind it by a quantity equal to their difference, or equal to $\frac{a}{n^2}$. In like manner, the next line on the vernier will fall behind the next on the scale by a quantity equal to twice the difference of the divisions, or equal to $\frac{2a}{n^2}$. The third on the vernier will fall behind the third on the scale by $\frac{3a}{n^2}$; and so on to the n^{th} division on the vernier, which will fall behind the n^{th} on the scale by $\frac{na}{n^2}=\frac{a}{n}$, i.e. by a whole division; and therefore the n^{th} division on the vernier coincides with the $(n-1)^{\text{th}}$ on the scale. Conceive the scale to be a scale of inches, and suppose it divided into tenths; then $a=1$ inch, $n=10$, $\frac{a}{n}=\frac{1}{10}$ of an inch, and $\frac{a}{n^2}$ (the difference between a division on the scale and on the vernier) $=\frac{1}{100}$ of an inch; so that the $\frac{1}{100}$ of an inch is exhibited on the scale, though its divisions are only to tenths.

The vernier is connected with the scale in such a way that it can be moved along it by means of a rack and pinion, a tangent screw, or some similar contrivance, and its zero be brought to coincide with any point on the scale. If, when the vernier is thus adjusted, its zero coincides exactly with a division on the scale,



the measure is read off at once; but if (as must generally happen) the zero falls between two of the divisions on the scale, then some one of the lines on the vernier will coincide, or very nearly coincide, with one of the divisions on the scale, and the distance of the zero beyond the last division on the scale behind it is expressed in hundredths by the number of the division on the vernier which is coincident with a division on the scale. Suppose, for example, the position of the vernier with respect to the scale to be as represented in the annexed figure, where the zero of the vernier is brought to coincide with a certain point p on the scale. The point p is read on the scale 29 inches, $\frac{2}{10}$, and a fraction which is to be measured by the vernier. Here the division 6 on the vernier coincides with that which is marked 8 on the scale; therefore the distance of the zero of the vernier from the last division 2 behind it on the scale is $\frac{6}{100}$ of an inch; for as 6 on the vernier coincides with 8 on the scale, the distance of 5 from 7 is $\frac{1}{100}$; of 4 from 6, $\frac{2}{100}$; of 3 from 5, $\frac{3}{100}$; of 2 from 4, $\frac{4}{100}$; of 1 from 3, $\frac{5}{100}$; and of 0 from 2, $\frac{6}{100}$. In like manner, if the vernier were pushed along till the division 8 coincided with 30 inches on the scale, then the reading of the zero point would be 29 inches $\frac{2}{10}$ and $\frac{8}{100}$. If, when the zero is brought to coincide with p, none of the divisions on the vernier coincide exactly with a division on the scale—for example, if the 5 on the vernier should be a little past the 7 on the scale, and the 6 not up to the 8—the reading would be between $\frac{5}{100}$ and $\frac{6}{100}$; but its precise amount could only be stated by estimation. If the line 5 appeared nearer 7 than 6 to 8, the distance measured would be greater than $\frac{5}{100}$, or $\frac{10}{200}$, but less than $\frac{11}{200}$; and if the line 6 appeared nearer to 8 than 5 to 7, the distance would be greater than $\frac{11}{200}$, but less than $\frac{12}{200}$ or $\frac{6}{100}$. Thus in any case the limits of the uncertainty must be confined within a distance $=\frac{1}{200}$ of an inch. In order that the coincidences may be observed with greater certainty, the divisions are usually read with a lens.

The vernier is equally applicable to circular scales, such as astronomical circles; it is then circular also, and must move concentric with the limb of the circle. Suppose the limb divided into intervals of $10'$; and let $n=10$. We have then 10 divisions on the limb $=100'$ $=a$; and the length of the vernier

$$=a-\frac{a}{n}=100'-10'=90';$$

which, divided into 10 equal parts, gives $9'$ for the length of a division on the vernier, and consequently the difference of the length of a division on the scale and on the vernier $=1'$. The arc, therefore, can be read to minutes. But the reading may be carried to much more minute quantities by increasing the length and the number of divisions on the vernier. Instead of embracing 9 intervals of $10'$ on the scale, let the vernier embrace 59 such intervals, and be divided into 60 equal parts. We have then $a=10'\times 60=600'$, $n=60$, $n^2=3{,}600$; therefore $\frac{a}{n^2}=\frac{600'}{3{,}600}=\frac{1'}{6}=10''$; i.e. the arc may be read to $10''$.

In barometers, where a considerable degree of accuracy is required, the inch is divided into 20 equal parts; the vernier is made equal in length to 24 of these, and divided into 25 equal parts. In this case we have $a=\frac{25}{20}=1{\cdot}25$ inch, $n=25$; therefore $\frac{a}{n^2}=\frac{1{\cdot}25}{625}=0{\cdot}002$; so that the vernier gives the reading to $\frac{1}{500}$ of an inch.

Instead of making the vernier equal to $n-1$ divisions of the scale, it is sometimes made equal to $n+1$ divisions, and the object will still be accomplished in precisely the same manner. For in this case the length of a division on the scale being as before, $\frac{a}{n}$, and that of a division on the vernier $\frac{1}{n}\left(a+\frac{a}{n}\right)=\frac{a}{n}+\frac{a}{n^2}$, the

difference is still $\frac{a}{n^2}$. The principle is the same in both cases.

The vernier is often called a *nonius*, but improperly, the contrivance invented by Nonius or Nunnez being on a quite different principle. [NONIUS.]

Veronica (a word made up from the Lat. vera, *true*, and icon, Gr. εἰκών, *an image* or *likeness*). A creation of Christian legend, which asserted that as Christ was led to crucifixion Veronica put a handkerchief to His face, and so obtained a true likeness. This relic is still exhibited at Rome. Alban Butler, who accepts the relic as genuine, thinks that there is not sufficient warrant for asserting that the saint who obtained it was named Veronica.

VERONICA (said to be from Arab. viroo nikoo, *beautiful remembrance*). A large genus of Scrophulariaceous plants, consisting of herbs or undershrubs, many of which are cultivated to adorn our flower borders and greenhouses. Their flowers are generally produced in close elongated spikes, and the blue colour predominates.

Verrucæ (Lat. *warts*). In Botany, the name applied to warts or sessile elevations of a glandular nature such as occur gregariously on the surface of different organs.

Verrucose (Lat. verrucosus, from verruca, *a wart*). In Botany and Zoology, when a surface presents several wart-like prominences.

Versatile (Lat. versatilis). In Botany, a term applied to bodies so placed that they swing freely, as the oscillating anthers of grasses. It is chiefly applied to anthers.

Verschaffeltia (after Ambroise Verschaffelt, a Belgian nurseryman). A genus of *Palmæ*, comprising a very handsome species, recently introduced into Europe from the island of Seychelles, and at first distinguished by the temporary name of *Regelia majestica*. The fruit is globose, drupaceous, with the scar of the stigma basilar; and the albumen is ruminated so as to form a kind of network. The species, called *V. splendida*, has a simple erect stem, clothed with spreading black needle-shaped spines; and the fronds are broad and entire, with the apex parted in two widely separate points, and the edges serrated.

Verse (Lat. versus, from verto, *I turn*). This word designates in its popular sense a line of a metrical composition, in opposition to *prose*. The division of the books of the Old and New Testaments into verses was applied in the earliest MSS. to those parts of the text in which the language of poetry is employed. The steps through which a similar division came gradually to be used throughout the whole of the biblical volumes are curious, and have been traced with great labour and particularity by Mr. W. Wright (*Cyclopædia of Biblical Literature*). Henry Stephens (Etienne Stephanus), the great French printer, has the credit of having finally established the present system, in the middle of the sixteenth century. The first English Bible in which it was adopted was the Geneva (1562), whence it passed into the Bishops' (1568), and Authorised Version (1611).

VERSE. [POETRY; RHYME; RHYTHM.]

Versed Sine of an Angle. In Trigonometry, the difference between unity and the cosine of the angle.

Version (Lat. versio, *a turning*). The use of this word in literary language is chiefly confined to the various translations of the books of the Old and New Testaments from the originals into later or modern languages. The ancient versions of the Old or New Testament, or both, known to scholars, are: the Æthiopic, Arabic, Armenian, Chaldee (Targum), Egyptian, Greek (Septuagint), Latin (Vulgate), Samaritan (Pentateuch), Syriac. The *authorised version* of the Scriptures in English was commenced in 1606, under the auspices of James I., by fifty-four scholars selected by him, and first published in 1611. (See the essays of Mr. Deutz and Mr. Plumptre, under these heads, in Smith's *Dictionary of the Bible*.)

Versor. [QUATERNIONS.]

Verst. A Russian measure of length containing 3,500 feet; about two-thirds of an English mile.

Vert (Fr.; Lat. viridis, *green*). In Heraldry, one of the colours or tinctures employed in blazonry. It is equivalent to emerald among precious stones, to Venus among planets. In engraving, it is represented by diagonal lines from the dexter to the sinister sides of the escutcheon.

VERT. [VERDURER.]

Vertebra (Lat.). This term, restricted in Anthropotomy to certain movable portions of the segments of the skeleton of the trunk, is now applied in Anatomy to the entire segment; which consists, in its typical state, of a *centrum*, *two neurapophyses*, and a *neural spine*, two *hæmapophyses* and a *hæmal spine*, and two *pleurapophyses*. The principal processes of a vertebra, which are usually exogenous, are, the *parapophyses*, the *metapophyses*, the *hypapophyses*, the *diapophyses*, the *anapophyses*, and the *zygapophyses*. The endoskeleton of the vertebrate animals consists of a series of such segments or vertebræ, some of which may support a pair of *diverging appendages*, and two pairs of such are usually developed into limbs.

Vertebræ (Lat.). In Human Anatomy, the bones of the spine. They are divided into *true* and *false*; the former constituting the upper, and the latter the lower portion of the spinal column. The true vertebræ are further divided into those of the neck, back, and loins; or the *cervical*, *dorsal*, and *lumbar* vertebræ. There are seven cervical vertebræ: the first of which supports the head, and is called the *atlas*; the second is the *dentata*: it has a tooth-like process, forming a kind of pivot upon which the head rotates. The dorsal vertebræ are twelve in number, and the lumbar vertebræ five. In the neck the spine projects forwards; it is then curved backwards in the thorax, and in the loins again projects for-

wards. There is an elastic substance between the vertebræ, admitting of a certain degree of motion; small between the individual bones, but considerable as affects the whole column. The vertebræ, and their projections or processes, afford attachments for a number of muscles and ligaments; and the spinal marrow is lodged in the bony canal formed by their several perforations.

Vertebrates (Lat. vertebratus, *having joints*). The name of a primary division of the animal kingdom, including those which have a cerebro-spinal nervous axis, protected by a bony cylinder composed of a succession of vertebræ, which are expanded into a cranium, where they enclose the enlarged anterior or upper portion of the nervous axis, called the *brain*. [Zoology.]

Vertex (Lat. literally *anything that turns*). In Astronomy, the point of the sphere directly overhead, more frequently called the *zenith*. The vertex of an angle or a cone is the point in which the sides of the angle or of the cone intersect. A vertex of a curve is any point in which a diameter meets the curve.

Vertical. Relating to vertex. *Vertical angles*, in Geometry, are the opposite angles formed by two straight lines which intersect each other. Euclid demonstrates that vertical or opposite angles are equal.

Vertical Circle. In Astronomy, a great circle of the sphere passing through the zenith and nadir. The meridian, and all azimuth circles, are vertical circles. The *prime vertical* is that particular vertical or azimuthal circle which is perpendicular to the meridian, or which passes through the eastern and western points of the horizon.

The term *vertical* is especially applied to the direction of a plumb line at any point of the earth's surface, or of the line which points to the zenith and is, therefore, perpendicular to the horizontal plane at the point.

Vertical Fire. [Fire of Artillery.]

Verticil (Lat. verticillus, *a whorl*). In Botany, a ring of organs of any kind placed round a stem upon the same plane. If the arrangement is not precisely thus, and cannot be described by a line drawn horizontally round a stem, but consists of parts either above the line or below it, the verticil is said to be broken. The verticil is commonly called a *whorl*.

Verticillate (Lat. verticillus). In Botany, a term used when several bodies form a ring round a common axis, as leaves round a stem, or the sepals, petals, and stamens round an ovary.

Vertigo (Lat.). Giddiness. This affection is a common symptom of disordered circulation in the brain, and of nervous and general debility.

Vertigo. In Zoology, a genus of marsh or land snails; so named from the abrupt twist of the volutions of the shell. Several species of this genus are British; as *Vertigo secale*, *Turtoni*, &c.

Vertumnus (Lat.). In Mythology, one of the Latin deities. From the connection of the name with the word *verto*, he was worshipped as being concerned with everything relating to change, in the seasons, merchandise, &c.

Vervain. [Verbena.]

Vesicants (Lat. vesica, *a bladder*). Substances which raise blisters upon the skin.

Vesicatorin. *Cantharidin*. The blistering principle of *Cantharides*, *Lytta*, *Mylabris*, and other blistering beetles. [Cantharides.]

Vesicle. A small blister or bladder-like tumour formed by an elevation of the cuticle, and containing a serous fluid.

Vesiculosans (Lat. vesiculosus, *full of bladders*). The name of a tribe of Tanystome Dipterous insects comprehending those which have the abdomen in the form of a bladder.

Vesper (Gr. ἕσπερος). The Latin name for the evening star, called by Hesiod a son of Astræus and Eos, and supposed to be the same as the morning star. Diodorus speaks of Hesperus as a son of Atlas, while Hyginus calls him a son of Eos and Kephalos. [Procris.] The evening star gave his name to western lands, as to Italy, which was Hesperia to the Greeks, and the name Greece has probably the same meaning. It is certain that the Hellenes did not call themselves Greeks, nor is such a people mentioned by any writer earlier than Aristotle, who speaks of the Græci as having inhabited a tract bordering on the Acheloüs, a district which would be Hesperian to those who dwell in the Eastern parts of the Hellenic land. Among the Bœotian towns mentioned in the catalogue of the second book of the *Iliad* is Graia, a name indicating possibly a western settlement during the earliest occupation of the country. The antithesis to Hesperia, or the land of the Graiæ, the kinsfolk of the Gorgons [Phorcos], is furnished by the Æthiopians, or dwellers in the glistering land, where the sun rises. But as the evening and morning star were supposed to be the same, so the Homeric Æthiopians live both in the far east and in the remotest west, where the sun goes down. (*Odyssey* i. 23.)

Vespers. One of the seven canonical hours, following nones and preceding compline [Hours], observed in modern times at two or three in the afternoon (but in Lent in the forenoon). The massacre known in history as the Sicilian Vespers was so called as having had for its signal the vesper bell of Easter Monday (March 30, 1282) at Palermo.

Vespertilionidæ (Lat. vespertilio, *a bat*). The name of a family of Cheiropterous Mammals, of which the genus *Vespertilio* is the type. It includes the insectivorous and blood-sucking species of the order.

Vespidæ (Lat. vespa, *a wasp*). A family of aculeated hymenopterous insects characterised by their geniculate antennæ, composed in the males of thirteen joints, and sometimes in this sex hooked at the extremity. Mandibles strong and dentated; clypeus large; ligula plumose or bilobed. The sting of the females and

neuters are long, powerful, and highly venomous. The larvæ of the wasp tribe are vermiform and without feet: those of the solitary species are enclosed separately in a cell, in which the mother deposits, at the same time with the egg, the bodies of insects, killed for the purpose, upon which the larva feeds.

Vesta (Lat.). One of the planetoids which circulate between the orbits of Mars and Jupiter. Vesta was discovered by Dr. Olbers of Bremen, on March 29, 1807. Its mean distance from the sun is 2·36108; the mean distance of the sun from the earth being unity; and its sidereal revolution is performed in 1325·7147 mean solar days. The orbit is inclined to the ecliptic in an angle of 7° 8′ 29″, and the eccentricity of its orbit is 0·08957. Vesta is supposed to be one of the smallest of all the celestial bodies with which we are acquainted, its volume being estimated to be only about $\frac{1}{15000}$ of that of the earth, and its surface not to exceed that of the kingdom of Spain. On account of its smallness it is, however, difficult to determine its apparent diameter with any degree of certainty.

VESTA. In Latin Mythology, a deity, identical both in name and in character with the Greek HESTIA, a word denoting *the hearth* on which the sacred fire was kept burning. She was thus inseparably connected with the PENATES, every dwelling-house being in a certain sense a temple of Vesta. Her temple in the Forum, like that at Tivoli, was round, and the lack of an image of the goddess was supplied by the perpetual fire kept up by the vestal virgins.

Vestal Virgins. This name was given to the six virgin priestesses of the goddess Vesta who had charge of her temple at Rome, and watched over the sacred fire, which was never to be suffered to go out. They had several privileges granted them; but the loss of their virginity was punished by burying the offender alive. Their institution is ascribed to Numa.

Vestibule (Lat. vestibulum). In Architecture, an area before the entrance of a house; said by some to have been so called because an altar to Vesta was placed therein.

Vestibule of the Ear. A small bony cavity of the internal ear, the opening of which into the cavity of the tympanum is closed by the small bone called the *stapes*: it is also connected with the cochlea and semicircular canals.

Vestments or Vestures, Ecclesiastical. Articles of dress or ornament worn by ministers in the celebration of divine service. The following were and are the principal known to the Western church, and many of them to the Eastern also: 1. The *vestment* properly so called, or *chasuble*, called in the Western churches *casula, planeta, pænula, amphibolum*, &c. and in the Eastern *φαινόλιον, phenolium*, was in its primitive form a perfectly round garment with an aperture in the centre for the head. When the offices were performed, it was lifted up at the sides, while the front and back remained pendent. The Greeks retain this primitive form; in the Western church it has been made to take the shape of a vesica piscis. It admitted of various materials and colours. It is of very great antiquity, being mentioned by Gregory of Tours, and appearing in a mosaic of A. D. 540. 2. The *cope* (*cappa, pallium, pluviale*, &c.) is in shape an exact semicircle with a border or orphrey on the straight side, and is fastened across the chest by a clasp called a *morse*. A hood for use was anciently attached to it; but only the form of one is now retained on it, to serve as an enrichment with embroidered work. It is also of great antiquity in the Western church. 3. The *tunicle* or *dalmatica* (called in the East *sticharion*, used by deacons), received the addition of wide sleeves as early as the fourth century. 4. The *alb* (*camisia, alba, linea*; in the East *poderis*, from reaching to the feet), a garment made of white linen, with tight sleeves, and secured round the waist by a girdle. 5. The *stole*, spoken of by the name of *orarium* as early as the council of Laodicea, A.D. 360. It is a narrow band, widened at the end to admit of an embroidered cross, and ending with a fringe. 6. The *pall* [PALLIUM], generally worn by Western metropolitans, is a circle of plain white lamb's wool with a pendant before and behind, reaching down to the feet. 7. The *rochet*, a linen garment much resembling the surplice; it is made either with or without sleeves. 8. The *chimere, simarra, cimar*, is properly a kind of cope with apertures for the arms to pass through. 9. The *pastoral staff* (*baculus pastoralis*) was spoken of in the fourth council of Toledo, in the seventh century, as used by bishops. The form of the shepherd's crook is rather later. 10. The *surplice* is a loose flowing garment of linen with expanding sleeves, worn by ecclesiastics of all ranks.

Most of these vestments are noticed in the Act of Uniformity, passed in the 2nd year of Edward VI., which regulates the habits of the English church.

For further details, see the *Directorium Anglicanum*, p. 13 &c.; Pugin, *Glossary of Ecclesiastical Ornament and Costume*.

The discussions which have been recently raised within the church of England on the question whether certain vestments are, or are not, lawfully used by ministers, have turned chiefly on the enactment of the Act of Uniformity, 1 Eliz. c. 2 s. 25, that 'such ornaments of the church and of the ministers thereof shall be retained and be in use, as were in this church of England by authority of parliament in the second year of the reign of King Edward VI. until other order shall be therein taken by the authority of the queen's majesty with the advice of her ecclesiastical commissioners or of the metropolitan.' The reference seems to be to the 'Book of the Common Prayer and Administration of the Sacraments,' ordered to be used in King Edward's Act of Uniformity, 2 & 3 Edw. VI. c. 1. But inasmuch as no certain know-

ledge can be arrived at as to the vestments really intended, and as Queen Elizabeth did not literally take any such 'order therein' as her Act of Uniformity seems to contemplate, that party in the church which is anxious to approximate as far as may be to the ceremonial of the church of Rome contends that vestments, at any time in use, and not expressly prohibited, are permissible. The question has now become complicated by ingenious and contradictory legal opinions, nor can it be solved, if its solution is deemed important, except by legislation.

Vestry (Lat. vestiarium, *a wardrobe*). The robing room attached to a church; and hence applied to designate a meeting of parishioners for parochial purposes, the bishop and priests having in former times used these rooms when they met to consult together on similar affairs.

A *general vestry* is one to which every parishioner or outdweller assessed to or paying the church rates, or scot and lot, is admissible of common right. The minister, when rector, vicar, or perpetual curate, is generally considered as entitled to be chairman of the meeting. The powers of the vestry extend to investigate and restrain the expenditure of parish funds; to determine on repairs, enlargements, ornaments, &c., of the church; and to elect certain parish officers. Several Acts of Parliament have been passed for the regulation of general vestries. (Stat. 58 Geo. III. c. 69; 59 Geo. III. c. 85; 16 & 17 Vict. c. 65, which do not apply to the metropolis. See, too, stat. 1 & 2 Wm. IV. c. 60, as to parishes in towns.)

Select vestries existed by custom in many large and populous parishes, especially in and round the metropolis. Originally these consisted of a number of householders annually elected by the ratepayers. But, by usage of long standing, these bodies were in many instances self-elected; i.e. the members of the vestry filled up by their own choice any vacancy occasioned by death or resignation.

Power has been given to parishes in which select vestries did not exist by custom to appoint such vestries, by stat. 59 Geo. III. c. 12; and in many parishes the election of vestrymen, &c. has been regulated by local Acts.

The functions of select vestries, as regards the relief of the poor, are now regulated by the Poor Law Acts.

Vesuvian. *Volcanic Garnet.* The name given by Werner to the IDOCRASE of Haüy, after the locality, Vesuvius, where it was first noticed in ejected blocks, associated with Mica, Hornblende, &c. It is of a hair-brown or olive-green colour.

Vesuvian Garnet. A name for LEUCITE, originating in the trapezohedral form of the crystals, which are similar to those of Garnet.

Vetch (Lat. vicia, Ital. veccia). The name given to a family of leguminous plants with herbaceous stems, which often support themselves on surrounding objects by means of the tendrils with which their leaves are terminated. The common Vetch or Tare is extensively cultivated in Europe, and furnishes an excellent fodder for milch cows and working stock, &c.

Veteran (Lat. veteranus, from vetus, *old*). Among the Romans, a soldier who had passed the legal age of military service was termed *veteranus*.

Vetiver. [VITTIE VAYR.]

Veto (Lat. *I forbid*). In Politics, the power enjoyed by a branch of the legislature, which cannot of itself originate or modify a law, to reject the propositions of the other branch or branches. In the Polish diet, every noble who was an independent member could prevent any resolution from passing by his simple dissent (expressed in the words, 'Nie pozwalam,' *I do not permit*). This privilege, termed the *liberum veto*, was the fertile source of disorders and anarchy in that country. In most constitutional monarchies the king has an absolute veto; in some it is only suspensive. Thus, in Norway, if three successive storthings (assemblies) repeat the same resolution, it becomes law against the will of the king. The president of the United States may return a bill, with his reasons for dissenting from it, to the house in which it originated; but if both houses pass it afterwards by a majority of two-thirds in each, it is not in his power again to reject it.

VETO. An Act passed by the General Assembly of the Church of Scotland, known by the name of the Veto Act. Lay-patronage has never been cordially recognised on the part of the people of Scotland. On the final establishment of Presbytery as the national church, in 1690, patronage was vested in the elders and heritors (landowners) of a parish. In 1711 (10 Anne c. 12. s. 4) that law was annulled, and patronage was transferred as a civil right to individuals as an accessory of land, or as a separate estate; and those patronages which had of old belonged to the pope, or to monasteries, or to archbishops, bishops, and chapters, were vested in the crown. The Act of Queen Anne was never universally acceptable in Scotland. Two dissenting denominations (the United Associate Synod, and the Relief) owed their origin to the indiscreet exercise of lay-patronage; and though patrons were generally disposed, particularly within the last twenty years, to show due deference to the feelings of the people, yet hostility to this mode of nominating clergymen having gained greater force, the General Assembly, in 1834, passed the Veto Act, whereby, if a majority of the male heads of families, in full communion with the church, appear before the presbytery and dissent, or lodge dissents at the meeting for *moderating in a call*, the presentee was to be rejected. Those entitled to dissent are ascertained from a roll annually made up. The Veto Act was first passed as an interim Act; but having received the sanction of the majority of presbyteries, it was enacted into a standing law of the church by the General Assembly of 1835. (Hill's *Practice of the Judicatories of the Church*, p. 83.)

Against the provisions of this Act, the minority of the Assembly recorded, both in 1834 and 1835, their solemn protest, on the ground that these provisions were not merely wrong in themselves, but that they were likely, on the first occasion on which a patron or presentee should determine to enforce his rights, to lead to a collision between the ecclesiastical and civil courts. The issue was raised in 1835 in an action brought against the presbytery of Auchterarder for rejecting Mr. Young, who had been presented to the living by the earl of Kinnoull. In giving judgment in this action, the court of session (March 8, 1838) held that the presbytery had acted illegally, and to the hurt and prejudice of the pursuers, and in particular contrary to the provisions of the statute of 10 Anne.

This decision of the court of session was appealed from by the defenders to the House of Lords, which affirmed the judgment in question (May 3, 1839) without the alteration of a single word.

Meanwhile the dominant party of the church, resolving not to obey the judgment of the court of session, though confirmed by the higher court to which they themselves had appealed, refused to induct Mr. Young as minister of Auchterarder. They regarded the parish as still vacant, and nominated a clergyman of their own sentiments to the parochial charge, quoad spiritualia, leaving the temporalities untouched.

This conflict was followed by others of a like kind in the presbyteries of Strathbogie and Garioch. In the latter, a majority inducted the presentee (Mr. Middleton) to the parish of Culsalmond, although he been served with a veto. The ecclesiastical courts promptly interfered; but interdicts against their authority were obtained: and the case having been carried to the House of Lords, a decision was given in favour of the presentee, thus declaring that the General Assembly had no power to pass the *veto act*, and that all proceedings under it were null and void. Indignant at this judgment, the leaders of the dominant party in the Assembly determined to secede from the church, and on the first day (May 18, 1843) of the meeting of the General Assembly, the members of that body who were in favour of the *veto*, having given in a written protest, constituted themselves a body to be denominated the FREE CHURCH OF SCOTLAND.

Vexillarii (Lat.). Veteran troops in the Roman army, who, having served out their time, were retained in service, and fought under a standard of their own (vexillum).

Vexillary (Lat. vexillarius). In Botany, that form of æstivation in which one piece is much larger than the others, and is folded over them, as in papilionaceous flowers.

Vexillum (Lat. *a standard*). In Botany, the standard or fifth petal placed at the back of a papilionaceous corolla.

Via Lactea. [MILKY WAY.]

Viaduct (Lat. via, *a way*, and duco, *I lead*). A bridge for carrying a road or railway across a valley at such a height as to maintain the general level of the line. As a stream of water runs in the bottom of most valleys, most viaducts have also to cross a stream of greater or less breadth; hence the definitions of a *bridge* and a *viaduct* are not very different. [BRIDGE; TUBULAR BRIDGE.]

Viaducts, like bridges, are formed of stone, brick, timber, cast iron and wrought iron. For important bridges, and viaducts of every kind, iron is now the material commonly preferred.

Iron bridges, of rude construction, but great antiquity, are to be found in Thibet and China. But the first iron bridge constructed in England is that of one arch, over the Severn, near Colebrook Dale, which was designed by Mr. Pritchard, about 1773, and completed in 1779. In this bridge five arched ribs of cast iron support perpendicular spandril pieces, which carry the roadway, and these ribs, which are nearly semicircular, have a span of 100 feet. Sunderland bridge, over the Wear, also of one arch, was the next iron bridge constructed, and was designed by Mr. Rowland Burdon in 1792. This bridge consists of 6 segmental ribs of 200 feet span, and 30 feet rise. Each rib is 5 feet deep, and consists of 105 separate pieces. Buildas bridge, over the Severn, also of one arch, by Telford, followed in 1816. It has a span of 130 feet with a rise of 27 feet. Boston bridge, by Rennie, has a span of 100 feet with a rise of 4 feet; and Southwark bridge, by Rennie, in 1818, has three arches, the centre one of 240 feet span and the side ones of 210 feet span. Telford's design for crossing the Thames by a single cast-iron arch was not carried out.

The rise and progress of the railway system led to the construction of railway bridges of many different kinds. In the earlier iron bridges the material was used in compression alone, as if it were a superior kind of stone. But the girder principle, which had been successfully introduced by Boulton and Watt for supporting great weights in mills and manufactories, was adopted in many railway bridges, sometimes in the form of simple cast-iron girders and sometimes trussed with wrought iron.

The failure, however, of one of these trussed girders in the case of a bridge upon this principle carried across the Dee, near Chester, discredited the system, and girders of wrought iron then began to be introduced. Such girders when applied to large spans naturally expanded into two systems; one the tubular system, as exemplified in the Menai bridge, and the other the lattice system, which last is now very generally employed in the case of deep girders suited for large spans. One very creditable example of this species of bridge is that which carries the London, Chatham, and Dover Railway across the Thames at Blackfriars, and in

which the girders rest on clustered columns of cast iron set upon strong cylindrical bases of stone.

The Crumlin viaduct on the Newport, Abergavenny, and Hereford Railway, in Wales, is formed of cast and wrought iron. The total height from the bed of the stream to the rails is 200 feet; distance from centre to centre of piers, 150 feet; total length of viaduct, 1,200 feet. The piers are formed of clusters of cast-iron columns, placed in stages. Each column is 17 feet long, by 1 foot diameter, and from 1 inch to $\frac{7}{8}$ of an inch thick. The number of columns in each stage is 14, and they are arranged in four rows of three each, with one at each side of each pier, which gives it a salient angular outline. The width between the columns at the base of each pier measures 13 feet 6 inches in every direction, except between the centre rows, where it measures 6 feet throughout the height. At the top of the piers the width between the columns is reduced to 9 feet. Measuring from the centres of the columns, the dimensions of the pier at the base are 60 feet by 27 feet, and at the top 30 feet by 18 feet, making a diminution of 30 feet in one direction and 9 feet in the other; to effect which all the columns except the central ones are made to lean correspondingly. The columns are trussed sideways to one another, and are fitted endways to one another with socket joints, a projection of half an inch being left on the top of each, which fits into a corresponding recess in the base of the one above it; and the surfaces, which are truly turned, are held together by four bolts at each joining passing through lugs. The foundations, which are of strong masonry, are generally carried down to the rock. The girders are made on Warren's principle, and consist of a stout beam above, a tie below and diagonal filling. The girders are 150 feet long and 14 feet 6 inches deep. The dimensions of the top tubular beam or girder are $14\frac{1}{2}$ inches by 9 inches, the sides being of inch plates, and the top and bottom of $\frac{1}{2}$-inch plates. The ties at the bottom of the girder consist of four wrought-iron bars of 6 inches by $\frac{5}{8}$ of an inch. There are 18 diagonals to each girder, and towards the centre they are strengthened by plates. This viaduct, which was opened in 1857, contains 1,300 tons of wrought iron, and 1,250 tons of cast. The high-level bridge at Newcastle is constructed of cast iron, and is formed with two platforms, of which the upper carries the railway, and the lower the common road. It consists of 6 spans of the average width of 125 feet, and the height is $108\frac{1}{2}$ feet. The piers measure 50 feet by 16 feet, and are lightened by arches.

The Chepstow and Saltash bridges are, in a certain sense, suspension bridges, in which a platform, carrying the roadway, is supported by ties and chains. But the towers, instead of being tied back by chains, are strutted asunder from one another by great wrought-iron tubes. The Boyne bridge on the Dublin and Belfast Railway is formed on the lattice-girder principle, the main span being 264 feet, and the two side ones 137 feet.

Suspension bridges have not usually been deemed suitable for railway purposes, inasmuch as the existence of a load at any one spot was supposed to be likely to throw the bridge out of shape, by sinking it at that place, and raising it at some other. This derangement, however, it is obvious, would be prevented by a properly stiffened roadway, which would also prevent the roadway from being put into waves in high winds; and Mr. Roebling, in 1848, threw a suspension railway bridge over the St. Lawrence just below the falls of Niagara, the breadth of the chasm being 800 feet, and the height of the bridge above the water 245 feet. This bridge consists of wire cables supporting a rectangular tube 20 feet deep by 26 feet wide, or rather two floors 18 feet apart, the upper carrying the railway, the lower a roadway for ordinary traffic. By bracketing out from the rocks, the free length of the tube is reduced to 700 feet, and it is then suspended from towers 82 feet apart from centre to centre by 4 wire cables of 10-inch section, and each containing 3,640 separate wires. When a train weighing 300 tons passes over the bridge, the deflection is said to be only 10 inches. If the published accounts are to be believed, this suspension bridge, or viaduct, cost only 100*l*. per foot forward. The total span is 822 feet.

The following are some examples of ordinary viaducts of various kinds:—

The Victoria bridge across the St. Lawrence at Montreal, constructed on the same principle as the Menai tube [Tubular Bridge], is made with a single tube 6,592 feet long in 25 spans, the central one of 330 feet, and the other 24 of 242 feet each. The masonry of the piers cost 114*l*. per foot of the bridge, and the ironwork 57*l*. The cost of the masonry of the piers has been greatly increased by the necessity of making them of great strength, and with sharp underlying spurs pointing against the stream at each pier, to resist and break up the masses of ice which are brought down the river in the spring when a thaw begins.

The Soane bridge on the line of the East Indian Railway connecting Calcutta with Benares, is of a length not much inferior to that of the Victoria bridge across the St. Lawrence. During a part of the year the Soane is a small river, but in the rains it rises forty or fifty feet, and spreads over a wide bed. The bridge consists of lattice girders resting on piers, and the piers rest on wells, which are built up with solid masonry, and constitute a great pile or pillar of brickwork, capable of sustaining a very heavy load. Bridges similar to that over the Soane have been built over the Jumna at Allahabad and Delhi.

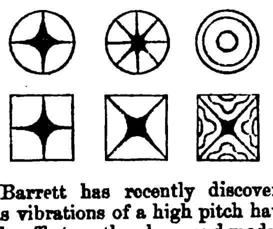
Mr. Fowler's viaduct across the Severn, at Oldbury Sands, is 4,131 yards long, and the principal opening for the navigation is of 600 feet span, and 95 feet high.

Viaticum (Lat. *supplies for a journey*). In the Church of Rome, the Eucharist when administered to dying persons is so called. It is given with extreme unction, but only to those who are in full possession of their faculties.

Vibration (Lat. vibratio, from vibrare, *to shake*). In Mechanics, the reciprocating motion of a body, as of a pendulum, a musical chord, or elastic plate. The term *oscillation* is, however, more frequently used to denote a slow reciprocating motion, as that of the pendulum, which is produced by the action of gravity on the whole mass of the body; while *vibration* is generally confined to a motion with quick reciprocations, as that of a sonorous body, and which proceeds from the reciprocal action of the molecules of the body on each other when their state of equilibrium has been disturbed.

VIBRATION. In Music, that regular reciprocal motion of a body, which, suspended or stretched between two fixed points, swings or shakes to and fro. The vibrations of chords are the source of the different tones emitted. [SOUND.]

Vibrations of Elastic Plates. When thrown into vibration transverse to their length, elastic plates divide themselves into an even number of vibrating segments, each segment moving in a direction *opposite* to that of the adjacent part. It follows that the points of separation between two parts participate neither in the motion of the one nor of the other, and consequently remain at rest. In the case of thin elastic plates, the continuity of these points forms lines of repose, or *nodal lines*, the forms and positions of which are detected by placing the vibrating plate in a horizontal position, and strewing a small quantity of fine sand over its upper surface. This method of investigating the vibration of plates was discovered by Chladni, who, by the arrangement of the sand, obtained a great variety of figures which bear his name. A few of the simpler figures observed when a square and round plate are thrown into vibration, by means of a violin-bow, are here shown.



Mr. Barrett has recently discovered that sonorous vibrations of a high pitch have a remarkable effect on the shape and mode of combustion of a tall and voluminous flame of coal-gas. By means of a properly shaped burner, a smoky flame about eighteen inches long is obtained, which at the sound of a whistle shrinks down to half its height, spreads out laterally into a fish-tail appearance, and yields a largely increased amount of light, so long as the sound is sustained. By adjusting the shape of the burner or increasing the pressure of the gas, the flame may be rendered wonderfully sensitive to certain sounds, so that at the lowest whisper or the slightest noise the flame can be made to shrink. The term *sensitive flames* has been applied to jets of gas in this state. The cause of their susceptibility to the influence of sound appears to be this: the sonorous pulses throw the pipe which conveys the gas to the burner into vibration, and the flow of gas, being thereby urged to the centre of the tube and confined within narrower limits, issues from the burner with an increased velocity so long as the sound continues. Now a sensitive flame is one which on the slightest mechanical increase in the velocity, or (what comes to the same thing) the pressure, of the gas, will shrink and take precisely the appearance which it has when influenced by sound. In the same way a fish-tail flame can be made to flare either by increasing the pressure on the gas or by a musical note, the latter having been discovered in America by Dr. Leconte some time ago. Since their discovery in 1866, the subject of sensitive flames has been examined by Dr. Tyndall (*Phil. Mag.* February 1867), and a résumé of the whole matter is given in an article in the *Popular Science Review* for April 1867.

Vibrations of Musical Chords. [SOUND.]

Vibrionidæ. The name of a tribe of Animalcules, commonly known as microscopic eels, of which the genus *Vibrio* is the type. One of the species of this genus of Animalcules is parasitic upon wheat: they form a cottony mass in the interior of the grain, which, when the latter is ground, will not pass through the cloth, but remains behind in the bran. When full-grown, the *Vibrio tritici*, as this species is termed, attains a quarter of an inch in length; but the young are of such microscopic minuteness, that Mr. Bauer, the naturalist, has calculated that 50,000 of them might be contained in one grain of wheat. The disease thus occasioned is commonly termed *ear-cockles*. Scalding water has been mentioned as the most obvious remedy.

Vibrissæ (Lat.). In Mammalogy, the stiff long-pointed bristles which grow from the upper lip and other parts of the head. In Ornithology, the term is also applied to hairs which stand forward like feelers; or which in some birds, as the fly-catcher, point both upwards and downwards from the upper and under sides of the mouth; or which spread out on each side like a comb from the upper sides of the mouth only, as in the goatsucker, when they are termed *vibrissæ pectinatæ*.

Viburnum (Lat.: the ancients made use of the word *viburna* to signify any pliant branched plant, that could be used for tying or binding). An extensive genus of *Caprifoliaceæ*, consisting of shrubs natives of Europe, Asia, and North America, but not found in tropical regions. *V. Lantana*, commonly known

by the name of the Wayfaring-tree, is a large shrub generally found in hedges or woods. Its leaves and berries are astringent; the latter are used in Switzerland in the manufacture of ink, while the former yield with alum a yellow dye. The wood is white and hard, and useful for turnery purposes. The rind of the root is used to make birdlime. *V. Opulus*, the Gueldres Rose, furnishes in one of its varieties, having the inflorescence sterile, the well-known ornamental shrub called the Snowball tree. *V. Tinus*, the Common Laurustinus, a native of the South of Europe, which in Corsica forms large woods, is a valuable shrub, from its dense evergreen foliage, and its cheerful flowers, produced very early in the year.

Vicar (Lat. vicarius). A clergyman who has the care of a parish as incumbent, in the place of (vice) a lay or collegiate rector. [Tithes.]

A vicar in the church of England is the principal ecclesiastical person (*parson*) of his parish; the word *rector*, where there is a vicar, denoting only the owner of the rectorial tithes, and not the acting clergyman. The corresponding term in French (*vicaire*) denotes an assistant minister, whom we designate a *curate*, the French *curé* being the principal clergyman of a parish (in which sense the word *curate* is used in the English Liturgy), so that the terms *vicar* or *vicaire*, and *curate* or *curé*, have exactly changed places in the two languages.

Vicar Apostolic. In the Ecclesiastical language of the court of Rome, a person in episcopal orders, holding from the pope authority to exercise his office in certain defined countries and districts wherein there is no organised Roman Catholic establishment. Thus England was under vicars apostolic until of late years, and Scotland is so still. Very frequently the vicar has the titular dignity of bishop of some see formerly Christian and now suppressed, technically called *in partibus infidelium*. The *vicars apostolic* are under the direction of the Congregation de Propagandâ Fide. [Propaganda.]

Vicars of the Empire. In the German constitution, princes who had the right of representing the emperor in case of absence or interregnum. The king of the Romans, whenever there was one, was perpetual vicar. If there were none, the office was divided into two: the elector of Saxony exercised the vicariate in the two Saxon circles; the electors palatine, and of Bavaria, alternately in the remainder of the empire. They administered revenues, presented to benefices, received feudal homage, &c.

Vice-admiral. The grade of *flag-officer* next below an admiral. He ranks with a lieutenant-general in the army.

Vice-chamberlain. An officer of the royal household immediately under the lord chamberlain.

Vice-chancellor. The great increase of the business of the Court of Chancery has from time to time rendered necessary the appointment of assistant judges. One vice-chancellor was accordingly appointed in 1813, and two more were added in 1841 after the abolition of the equitable jurisdiction of the Court of Exchequer. Each vice-chancellor sits in a separate court, and takes a share of the general business of chancery; his decisions are subject to an appeal to the lord chancellor or the lords justices of appeal (who were in like manner appointed in 1851 to assist the lord chancellor). The judge of the local court of chancery of the duchy of Lancaster is also termed a *vice-chancellor*, as being the legal deputy of the chancellor of the duchy, an officer whose functions are political only. The chancellors of the universities also, though nominally the principal functionaries of those corporations, act for the most part only through vice-chancellors.

Vicegerent (Lat. vicem gerens, *holding the place of any one*). Any officer acting as deputy or lieutenant of another.

Viceroy or **Vice-king.** A title often applied in common usage to any officer representing the supreme authority in a dependency; e.g. the lord-lieutenant of Ireland. But it has seldom been officially given, except to the governors of certain dependencies of the old Spanish monarchy; such as Naples, Peru, and Mexico, each of whom bore the pompous title of *alter ego* of the sovereign.

Vicia (Lat. *a vetch*). A large genus of papilionaceous *Leguminosæ*, whose species are distributed throughout the temperate regions of the globe. They are weak plants, generally climbing, with pinnate leaves, which terminate in tendrils. *V. sativa* is the Tare or Vetch of our farmers, and is extensively grown as fodder for cattle. It is distinguished from most of the species growing in this country, either wild or cultivated, by its sessile solitary rarely twin flowers, and by its smooth seeds. The common Bean is sometimes included in this genus under the name of *Vicia Faba*. [Faba.]

Victim. [Sacrifice.]

Victoria (after Queen Victoria). This truly royal genus of *Nymphæaceæ* consists of an aquatic species of the highest interest from its beauty and curious conformation. It has thick fleshy rootstocks, sending up numerous long cylindrical leafstalks, traversed by air canals, and armed with stout conical prickles. The blade of the leaf is peltate, circular in outline, and when fully developed is from six to twelve feet in diameter, its margin uniformly turned upwards to the depth of two or three inches, giving the appearance of a large shallow tray, while the lower surface is traversed by very prominent nerves radiating from the centre to the margin of the leaf, and connected one with another by smaller nerves running transversely, so that the whole under surface is divided into a number of irregularly quadrangular compartments or open cells, by which the enormous leaves are well adapted to float on the water. The flowers when fully expanded have the

outer petals bent downwards, while the central rose-coloured ones, with the stamens, remain erect; and thus a noble appearance is presented, as of a central rose-coloured crown supported by a series of pure white and most gracefully curved petals. The fruit when ripe is a sort of globular berry, thickly beset with formidable prickles. These noble plants inhabit the tranquil rivers of South America, and especially the tributaries of the Amazon. The Spaniards call the plant Water Maize, as they collect the seeds and eat them roasted.

Victoria Cross. A British naval and military decoration. It consists of a Maltese cross of bronze, with the royal crest in the centre, and underneath an escroll bearing the inscription, 'For valour;' it is worn with a blue riband for the navy, a red riband for the army. It is ordained that neither rank, nor long service, nor wounds, nor any circumstance or condition whatsoever, save the merit of conspicuous bravery, shall be held to establish a sufficient claim to the honour. The royal warrant instituting the order bears date Jan. 29, 1856.

Victory (Lat. Victoria). In Roman Mythology, a goddess, called by Varro the daughter of Heaven and Earth. Her altar was preserved in the curia or senate house of Rome; and its destruction was the subject of one of the latest contests between Christians and Pagans. (Beugnot, *Destr. du Paganisme en Occident*, i. 410, 430; *Mém. de l'Acad. des Inscr.* vol. xviii. 21.)

Vicuna. [AUCHENIA; MELIDÆ.]

Vidame. In French Feudal Jurisprudence, originally an officer who represented the bishop, as the viscount did the court (vice-dominus). In process of time, these dignitaries erected their offices into fiefs, and became feudal nobles, such as the vidame of Chartres, Rheims, &c.; continuing to take their titles from the seat of the bishop whom they represented, although the lands held by virtue of their fiefs might be situated elsewhere.

Videlicet (Lat. contracted from videre licet, *it may be seen, it is clear*). In Law. In pleading, it is usual to state any allegation which forms part of the facts set out, but which it is not intended to prove with precision, with the words *to wit* preceding it, as where anything is alleged to have taken place heretofore, *to wit* on such a day. This is termed *putting a videlicet* or *scilicet*.

Videttes (Fr.). Sentries placed on outposts and elevated points, so as to be able to observe the approach or movements of an enemy.

Vierzonite. A kind of yellow ochre, found at Vierzon, Dépt. du Cher, in France.

View (Fr. vue). In Law, the inspection by a jury previously to trial of the place, on or with regard to which the matter in controversy has arisen.

Vigil (Lat. vigilia, *a watching*). In Ecclesiastical usage, the evening before a feast day is so termed. Originally celebrated by meeting together at night (as they are still on some occasions in the Eastern churches), the vigils preserve the memory of the nocturnal assemblies of Christians in times of persecution.

Vigna (after Dominic Vigna, a commentator on Theophrastus). A genus of *Leguminosæ*, founded upon plants originally referred to *Phaseolus* and *Dolichos*. *Vigna* is distinguished by its pods being nearly cylindrical, instead of flattened as in *Dolichos*, and by their being constricted between the seeds, which are separated from each other by thin spurious partitions. The species are dispersed over the tropics of both hemispheres, most numerously, however, on the American continent. They are herbs, with twining or prostrate annual stems, trifoliate leaves, and axillary flowers. [PHASEOLUS.]

V. sinensis is very extensively cultivated in the East, particularly in India, where its pulse is called Chowlee, and forms, in conjunction with rice, a considerable part of the food of the Hindus. The Chinese, who call the plant Tow-Cok, cook and eat the green pods as we do kidney beans. When ripe the pods are frequently as much as a yard long, and contain about twenty seeds, of variable colour and variously marked. A variety of it (*Dolichos melanopthalmus* of some authors) is cultivated in Italy and other parts of Southern Europe under the name of Fagiolo del Occhio.

Vignette (Fr.). A small ornamental engraving without complete background or bounding line, used in printing for the illustration or decoration of a page of any work.

Vignite. A mineral found in France, at Vignes, in the Moselle. It is probably a mixture of magnetic iron-ore, with carbonate and phosphate of iron.

Vikings. The Norse name of the piratical leaders, known to us as the Sea-Kings, whose assaults began in the ninth century.

Villa (Lat.). In Roman Antiquities, originally any country dwelling. Many descriptions of ancient villas are found in the pages of classical writers; but the two most complete (besides those contained in the work of Vitruvius) are the accounts given by Pliny the younger of his Laurentine and Tuscan residences (*Epist.* ii. 17, v. 6). To these may be added the pleasing, though over-ornamented poetical delineation of Statius, *Silvæ*, lib. 3, describing a magnificent residence overlooking the bay of Naples. The most important parts of an ordinary villa were the *porticoes*, one or more, along the front or sides of the mansion; the *triclinium* or dining room: the wings forming suites of apartments, commonly called, in the time of Pliny, *diætæ*; the *baths*, with their appurtenances, the *hypocausta* or vaulted heating rooms, *apodyteria* or dressing rooms, rooms for exercise (*sphæristeria*), &c. Adjacent to the main portico was generally the XYSTUS.

Village or **Vill** (Lat. villa, properly a *country house*). In English Legal phraseology,

this word appears formerly to have been nearly synonymous with *town*, denoting an assemblage of houses with or without adjacent land; but it is now applied usually to the principal body of contiguous dwelling-houses in a country parish. In countries where there are peasants attached to the glebe, or possessing distinct rights and obligations from other subjects, a village is properly a place inhabited by peasants only. From the Latin villa was derived the French ville, *city*, originally signifying any residence; and thence a collection of houses which gradually grew around a principal residence. Thus, especially in Normandy, *ville* is a common termination to the names of places, like *ton* or *by* in England; and consequently, also, of family names. The English *town* furnishes a parallel instance of the alteration of the meaning of a word produced by an increase of population, our original *towns* having been single residences or hamlets; and in Scotland at this day, a house with its appurtenances in rural districts is sometimes called *the town*.

Village System. In infant or rude agricultural communities, a peculiar form of communism is frequently recognised. The land is supposed to belong to all alike, and is portioned out in plots or strips for the labour of the several occupiers. The produce is stored in a common barn, and distributed according to the necessities of the inhabitants by the headman, who is also responsible for taxes and rents payable from the village. Relics of such a system are still to be recognised in the *lands* still or till lately found in the common fields throughout some of the midland and southern counties. The clan system of Wales and the Highlands, and the Irish gavelkind, with its attendant custom of tanistry, were modifications of the village system, which was common in Russia up to comparatively late times, and still exists in many parts of India.

Villarsite. A hydrated silicate of magnesia, resembling Serpentine in hardness and translucence, and in texture and colour very like certain kinds of phosphate of lime from Arendal. It occurs in small crystalline veins, and in brilliant translucent rhombic octahedrons; also massive and granular—of a yellowish-green or greyish-yellow colour; at Traversella in Piedmont in veins of magnetic iron-ore. Named after M. Villars.

Villein (Low Lat. villanus). According to the ancient law books, such as Glanville and Bracton, the villein of the early middle ages was absolutely dependent on his lord, was possessed of no chattels which the lord could not seize, and could be sold with his family into slavery at the lord's discretion, the only protection accorded to him being that of a remedy against atrocious personal injuries. It is further stated that villeins were *regardant* and *in gross*: the former being attached to the soil (ascripti glebæ), from which they could not be removed, though their services and chattels could be sold and enforced; the latter attached to the person of the lord, and therefore saleable as slaves. This distinction has been disputed by Mr. Hallam, who inclines to the view that the condition of villeins was exceedingly depressed.

Historical evidence, derived from contemporary documents, presents us, however, with a very different picture. The villein, in the thirteenth century at least, is in possession of land, which he holds permanently at labour or money rents, and which descends to his representatives on payment of a slight fine. A tax called a *heriot*, and generally in the form of his *best chattel*, is leviable from his estate on his decease, instead of all his chattels lying at the discretion of the lord. He is prohibited from quitting the manor, except a yearly rent or a round sum be paid, the rent or the charge for total emancipation being very small. He cannot send his son into the church or to the university without paying a similar fine, for to take even the lesser orders involved emancipation. He cannot marry his daughters without paying a fine, known as *mercheta*, *culage* or *jambage*. But he has his legal remedy in county courts against any one but his lord, being liable to him before the freeholders of the manor only, who were not likely to strengthen his lord's hands. He serves on juries, and has his vote for the knights of the shire up to the famous election statute of Henry VI., by which the franchise was limited to the forty-shilling freeholder.

If the state of the villein described by Glanville (*De Legibus Angliæ*) had ever any literal existence, a great change must have been effected during the long and obscure reign of Henry III. It is certain that the condition of villeins became better and better during the fourteenth and fifteenth centuries, and that they had become copyholders long before the Reformation. The last enfranchisement is found in the reign of Elizabeth, when a fine was paid, not we may be sure for social privileges, or legal equality, but for some larger rights over land. The latest plea of villenage alleged as a defence to an action was made in the reign of James I., but the court unanimously decided that servitude was unknown to the English law, and that the plea was bad.

For further information as to the condition of the peasantry during the thirteenth and fourteenth centuries, see Prof. Rogers' work on *Agriculture and Prices in England*.

Villenage (Low Lat. villenagium). The state of a villein, or of lands and tenements held by a villein.

Villi (Lat. villus, *the long hair of animals*). In Anatomy, the name given to minute vascular processes covering, in the proportion of about twenty-five to every square line, the surface (hence called *villous*) of the mucous membrane of the small intestine, and giving it a velvety or fleecy appearance. They promote the absorption of chyle from the completely digested food. Similar minute vascular processes of

the chorion and other membranes are called *villi*.

Villose (Lat. villosus, from villus). In Botany and Zoology, when a part is covered with soft flexible hairs thickly set.

Vinagrillo. A South American name for *Oxalis Acetosella*, used as a salad plant. The same term is also applied in Chili to dried cakes of pounded oxalis leaves, which are infused in water to make an acid drink.

Vinalia (Lat. from vinum, *wine*). According to Varro and Ovid, a festival in ancient Rome. There were two vinalia: the first in April, sacred to Venus; the second in August, to Jupiter. The latter was considered as the beginning of the vintage season, before which new wine was not permitted to be conveyed into Rome.

Vinatico. A coarse mahogany obtained in Madeira from *Persea indica*. It is one of the shipbuilding woods recognised at Lloyd's.

Vincetoxicum (a word coined from Lat. vinco, *to conquer*, and toxicum, *poison*). A genus of *Asclepiadaceæ*, the species of which were formerly referred to *Asclepias* and *Cynanchum*; most of them are natives of the Old World, and chiefly of Western and Central Asia, though a few are European. The root of *V. officinale*, or Swallow-wort, which is the common North European species, possesses drastic and emetic properties, and was formerly in some repute as a medicine, being employed in scrofula and skin-diseases, and also, particularly in Germany, as an antidote to poisons, whence it has been named Tame-poison. When fresh, it has a disagreeable odour, and an acrid bitter taste.

Vinculum (Lat. *a bond* or *tie*). In Algebra, a mark or character which connects several letters or quantities, and indicates that they are to be treated as a single quantity. Vieta first used the bar or line over the quantities for a vinculum, thus, $a \times \overline{b+c}$; meaning that the quantity a is to be multiplied by the sum of the quantities b and c. This manner of connecting quantities was generally used by the early English writers on algebra; but it is now more common to make use of the parenthesis, which is a much more convenient mode of notation, especially when the expression is somewhat long. Thus, instead of writing $a \times \overline{b+c}$, or $\sqrt{\overline{x^2 - 2xy + y^2}}$, it is more usual to write $a\ (b+c)$, $\sqrt{(x^2+2xy+y^2)}$. The parenthesis, which has generally been used by foreign mathematicians, is said by Hutton to have been first used as a vinculum by Albert Girard.

Vine (Fr. vigne, Lat. vinea). In Horticulture, the name of the Grape Vine, the fruit of which is in universal demand, either fresh, or dried as raisins. Its fermented juice forms Wine. [Vineyard; Vitis.]

The word *vine*, in Botany is often employed in a general sense to designate any stem which trails along the ground without rooting, or entangles itself with other plants, to which it adheres by means of its tendrils or by twining; as the cucumber and the hop.

Vine Mildew. The name applied to a white mould, to which of late years the vine has been very much subject. This mould makes its appearance on the leaves and young bunches of grapes, and produces either complete abortion in the fruit, or dwarf ill-shaped juiceless cracking berries; or where a little pulp has been formed, rapidly reduces the whole into a state of decomposition. The mould was named by Mr. Berkeley *Oidium Tuckeri*. Subsequent observations have confirmed a suspicion, which was before entertained, that the *Oidia* of this group are merely a peculiar condition of different species of *Erysiphe*; and it is generally allowed that such is the case with the vine mildew itself, though it has never been observed to make any further advance than the production of those peculiar cysts, known under the name of *pycnidia*, which accompany the true fruit of *Erysiphe*. The disease has spread in every direction, and many remedies have been proposed, among which the application of sublimed sulphur has been, when properly and perseveringly applied at a sufficiently early stage, almost uniformly efficacious. [Oidium.]

Vinegar (Fr. vinaigre, Lat. vinum acre, *sour wine*). This term is applied to various modifications of the acetic acid. The simplest mode of obtaining vinegar is to excite a second or acetous fermentation in wine: in this case oxygen is absorbed, a variable proportion of carbonic acid is generally evolved, and the alcohol of the wine passes into acetic acid. Very good vinegar is also made from strong beer, or from a wort or infusion of malt prepared for the purpose, or from a decoction of common raisins, or from a mixture of about 1 part of brandy with 8 of water and some sugar and yeast. The acetic fermentation is accomplished either in casks, or by allowing the alcoholic liquid to trickle slowly over shavings or twigs, a current of air passing in the opposite direction.

When vinegar is distilled, various impurities which it contains remain in the still, and the liquid which passes over is the acetic acid, nearly pure, but largely diluted with water. In this state it is usually called *distilled vinegar*, and is used chiefly in pharmacy. But though a considerable quantity of vinegar is made in wine countries by the first-mentioned process, and here and elsewhere by the second, in which malt is employed, yet for all the purposes of the arts and manufactures, as well as for domestic consumption, the market is chiefly supplied from another source, which is the destructive distillation of wood. It has long been known that when certain kinds of dry wood (especially beech and such woods as are not resinous), instead of being burnt in the open air, are converted into charcoal in close vessels, so as, in fact, to be submitted to destructive distillation, the vapours which pass off yield, when condensed, a large quantity of tar, and of very acid water. The latter is, in fact, an impure vinegar, i.e. it owes its acidity to acetic acid, which is formed during the pro-

cess out of the carbon, hydrogen, and oxygen of the wood, which elements are also those of acetic acid, and not in very different proportions. When this impure acetic acid is freed from the tar and empyreumatic oils with which it is mixed, it is called *crude pyroligneous acid.* To convert it into pure acetic acid, i.e. to separate from it the empyreumatic products with which it is intimately combined, is a somewhat circuitous process, of which the following is an outline: It is first distilled, by which *pyroxylic spirit* and *oil of tar* first pass over, and these are followed by a quantity of impure or rough acetic acid. This rough acid, which is used by dyers and calico-printers, and by makers of sugar of lead, is saturated with powdered slaked lime, and being filtered, yields a solution of impure acetate of lime, which is evaporated to dryness, and which, distilled with dilute sulphuric acid, yields a purer acetic acid than the former, but which still has a burnt and disagreeable flavour; it is therefore again saturated by lime, and this liquid acetate of lime is mixed with a solution of sulphate of soda, which, acting by double decomposition, yields a precipitate of sulphate of lime, and acetate of soda remains in solution. The latter salt is procured by evaporation, and purified by torrefaction and crystallisation. The vinegar makers, who purchase it, decompose it in retorts or proper stills, by means of sulphuric acid, by which a very pure and strong acetic acid passes over, sulphate of soda remaining in the retort. The acetic acid thus obtained, which is in its most concentrated state, is extremely acrid, sour, and pungent, and is often called *radical vinegar*, or, when perfumed, *aromatic vinegar*; it is also occasionally termed *glacial* acetic acid, from its property of congealing at a low temperature, and remaining frozen at temperatures below 50°. In this state it is a compound of 1 atom of real acetic acid = 51, and 1 of water = 9; the real or anhydrous acid, as it exists in the dry acetates, being composed of—

	Atoms	Equiv.	Per cent.
Carbon	4	24	47·06
Hydrogen	3	3	5·88
Oxygen	3	24	47·06
		51	100·00

proportions which are equivalent to 4 atoms of carbon and 3 of water. When this strong acetic acid is diluted with water and slightly coloured, it forms a very pure and excellent substitute for common vinegar, and is cheaper than acid of the same strength prepared in any other way.

The combinations of acetic acid with various bases are called *acetates*. The acetates of lead, copper, iron, and alumina, are chiefly employed in dyeing and calico-printing; the acetates of ammonia and of potash, which, as well as acetate of lead, are used in medicine; and the acetates of lime and of soda are employed in the preparation of strong acetic acid. The acetates are recognised by their solubility in water, and by the fumes of acetic acid which they evolve when acted upon by sulphuric acid. The specific gravity of the strongest liquid acetic acid is 10629; that of good malt vinegar is 10200; and that of distilled vinegar about 10023. The strength or value of vinegar, and of acetic acid, can be learnt only by its saturating power.

The manufacture of vinegar is chiefly confined to England, the quantity produced in Scotland and Ireland not amounting on the annual average to more than 100,000 gallons. The quantity of vinegar manufactured in England is over 3,000,000 gallons annually.

Vinegar Plant. A peculiar state of the mycelium of *Penicillium glaucum.* During the process of acetous fermentation of liquids, a coat of greater or less thickness, consisting of many layers separable the one from the other, is formed on the surface. This under the microscope is found to consist of interlaced delicate branched threads, which, if placed in circumstances favourable to their developement, give rise to a crop of *Penicillium glaucum,* a universally distributed mould. If a portion of this coat is placed in a solution of sugar and water, kept in a proper temperature, the whole is converted into vinegar far more rapidly than it would be without the presence of the fungous mass. It is therefore called the Vinegar Plant, and is much used in the manufacture of vinegar. The mode in which the Vinegar Plant operates on the solution is supposed to be similar to the action of the Yeast Plant.

Vineyard. A plantation of Grape Vines cultivated for the purpose of making wine. Vineyards at present are chiefly confined to the warmer parts of the Continent, but they were formerly to be met with in Britain, more particularly in the neighbourhood of religious establishments.

Among the last vineyards of which we have any account, are one at Haffield, near Ledbury, which belonged to the celebrated Jacob Tonson; one at Bury St. Edmunds; one in the Isle of Wight; and another at Pain's Hill, in Surrey. The ground chosen in all these cases was a sloping surface of dry gravelly or chalky soil, with a southern aspect; and the vines were planted in rows at four feet apart every way, and trained to short stakes about four feet high. Every year the shoots were cut down to within a foot of the ground, and not more than three shoots were allowed to be matured by each plant. Each shoot produced two or three bunches of grapes, and the shoots were shortened in the course of the summer so as never to reach higher than the stakes, to which they were tied with rushes previously cut and dried for the purpose, or with twigs of willow. The kinds of grapes grown were chiefly the Burgundy or large Black Cluster, and the small Black Cluster or Miller grape, so called from the white mealy appearance of the leaves. In fine seasons a tolerably good wine was produced.

On the Continent, the vineyards which produce

the best wine are invariably found on dry soils, more or less calcareous; and the most celebrated are on the dry sunny sides of granitic or calcareous hills, with the surface formed into terraces, like the steps of stairs on a large scale; each step or terrace being supported on the lower side by a stone wall, to which the vines planted at the base of the wall are sometimes attached, not by nails, as wall-trees are in Britain, but by hooked sticks driven into the interstices between the stones, such walls being for the most part built without mortar. In France and the South of Germany, vines are seldom allowed to grow higher than four feet; and they are cut down every year, after the crop has been gathered and the leaves dropped, to within one or two feet of the ground. In the neighbourhood of Stuttgard, and between that city and Heidelberg, where the sides of the hills are covered with vineyards, the shoots are not cut down before winter; but those of each stool or plant are bent down to the ground, where they are tied together with a straw band, and retained in that position by laying a stone on the bundle. This is for the purpose of preserving the vines from the extreme cold of winter; the shoots, when so laid prostrate, being soon covered with snow. In spring, the shoots are raised up again, pruned, and tied to stakes. In the north of Italy, and chiefly in the plains of Lombardy, the vineyards are managed much as in France; but in Tuscany, the Papal States, and Naples, the vineyards are interspersed with mulberry-trees, which are kept pollarded; and to these the vines are attached, partly by ties of willow and partly by their tendrils, and they produce bunches of grapes to the height of six or eight feet from the ground. Sometimes the shoots are trained to elms, mulberry-trees, or poplars, in which case they produce grapes to a much greater height.

Vingt-un (Fr.). A popular round game at cards. It depends on the number of pips in the cards dealt to each player; in reckoning which, the ace counts either one or eleven at pleasure, the court cards ten each, and the others according to the number of their pips. The object is to obtain the highest number, not exceeding *twenty-one*, whence the name.

Vinous Fermentation. The change which takes place in saccharine solutions in the presence of yeast. It consists in the splitting up of sugar into two atoms of alcohol and four of carbonic acid. [FERMENTATION.]

Viola (Ital.). A musical instrument of the same form and with the same number of strings as a VIOLIN, and, like it, played with a bow, but larger, and extending a fifth lower in compass. The English call it the *tenor violin*.

Violaceæ (Viola, one of the genera). A natural order of hypogynous Exogens, consisting of herbs or shrubs, of which between two and three hundred species are known, dispersed over nearly all parts of the globe. They have usually alternate and simple leaves furnished with stipules, and axillary flowers, either solitary, or in cymes, racemes, or panicles. They have the one-celled free ovary with parietal placentas (usually three) of *Bixaceæ* and their allies, but are distinguished by their stamens being almost always five in number, with very short filaments and comparatively large anthers, erect and often connate in a ring round the pistil—their connective often very broad, and produced into an appendage at the top, with the cells opening inside the ring. The flowers, when irregular, are often large and showy; and the capsule in the greater number of genera opens in three very elastic valves.

Violan. A mineral of a dark violet-blue colour found at St. Marcel, in Piedmont.

Violet (Lat. viola). The name of a well-known wayside flower, the *Viola odorata* of botanists. The odorous emanations of Violets, like those of some other flowers, are said by Pereira to have occasionally proved dangerous. Taken internally, the syrup acts as a laxative, while the root is emetic, and might even be employed as a substitute for ipecacuanha.

Violin (Lat. fides; Ger. fiedel; Dutch vedele; Old High Ger. fidula; Mod. Lat. vitula; Prov. viula; Ital. viola, and hence the dim. violino: Wedgwood, *English Etymology*, s.v. 'Fiddle'). A musical instrument, commonly called a *fiddle*, mounted with four strings, and played with a bow. It consists of three parts —the *neck*, the *table*, and the *sounding-board*; at the side are two apertures in the shape of *S s*. On it is a bridge, which bears the strings up from the belly, over which they pass from one extremity, called the *tail-piece*, to the other near the head, where they are received by turning pins, which tighten or loosen them at pleasure.

The violin is the most perfect of solo instruments, on account of its fine tone, its great capability of execution, and, still more, of expression, in which latter respect it has no parallel.

The best violins were those made at Cremona, in Italy, more than a century ago, and which still bear a high value.

The violin tribe of instruments constitutes the main element of every concert orchestra; there are four varieties generally used, viz. the *violin*, the *viola*, the *violoncello*, and the *double bass*.

Violine. An emetic principle contained in the root of the *Viola odorata*, or common violet.

Violoncello (Ital.). In Music, a bass violin with four strings.

Violone (Ital.). In Music, a large bass violin, commonly called a *double bass*. The Italian form of the instrument has three strings, the German four.

Viper (Lat. vipera, perhaps a contraction of vivipar; from vivus, *alive*, and pario, *I bring forth*). The common name of a genus of venomous serpents which produce living young, and have a head broader than the neck, and no pits behind the nostrils. The true vipers (*Vipera*) are distinguished by the head being covered with scales, like those on the back, and by the nostrils being very large. The horned viper of

North Africa and the puff adder of South Africa belong to this group. The adders (*Berus*) have the head covered with granular scales, with larger ones intermixed in some species, and have the nostrils of moderate size. The black adder and the common adder (*Berus chersea*), which are the only indigenous venomous reptiles of Great Britain, are examples of this group.

Virgate. [YARD.]

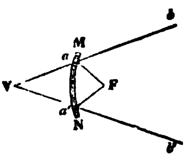
Virgilian Husbandry. [AGRICULTURE.]

Virginal. A musical stringed and keyed instrument of the harpsichord species, used in the sixteenth century. A book of exercises for the virginal, written for Queen Elizabeth, is still extant.

Virgo (Lat. *the virgin*). In Astronomy, one of the twelve zodiacal constellations, or signs, being the sixth in order, beginning with Aries. Virgo is usually represented with an ear of corn in her hand, and is hence called *Signum Cereris*. The sun enters this sign about the 22nd of August. The constellation Virgo contains one bright star of the first magnitude, called *Spica Virginis*.

Virola. Aublet, in his work on the plants of Guiana, established this genus upon one of the American Nutmegs, named by him *V. sebifera*; but modern botanists regard it and its allies as forming one of the sections of the large genus *Myristica*, consisting of large trees confined to tropical South America. *V. sebifera*, which forms a tree sixty feet high, is common in the forests of Guiana and North Brazil, and is found as far north as Panama. A solid oil or fat is obtained by macerating the seeds in hot water, and this is used in Guiana for making candles. An acrid red juice, employed medicinally by the Brazilians, exudes from wounds made in the bark.

Virtual Focus. In Optics, the point from which rays, having been rendered divergent by reflexion or refraction, appear to issue. Thus, let M N be a section of a metallic speculum, F a radiating point, F a, F a' rays falling on the speculum at a and a', and reflected into the directions $a\,b$ and $a'\,b'$; then the point V, in the concourse of the straight lines $a\,b$ and $a'\,b'$, is called the *virtual focus* of the reflected rays. [REFLEXION.]



Virtual Velocity. In Mechanics, the velocity which any point of a body in equilibrium would actually acquire during the first instant of its motion if that equilibrium were disturbed.

The general principles on which the laws of equilibrium in machines are established may be reduced to three; viz. the principle of the *lever*, the principle of the *composition of forces*, and the principle of *virtual velocities*. The last consists in this, that two forces are in equilibrium when they are in the inverse ratio of the virtual velocities of the points to which they are applied, estimated in the direction in which the forces respectively act. The principle is thus enunciated generally by Lagrange (*Mécanique Analytique*, p. 22):—

'If any system of bodies or material points, urged each by any forces whatever, be in equilibrium, and there be given to the system any small motion, by virtue of which each point describes an indefinitely small space, which space will represent the virtual velocity of the point; then the algebraical sum of the forces multiplied each by the space which the point to which it is applied describes in the direction of that force, will always vanish, regarding as positive the small spaces described in the direction of the forces, and as negative those described in the opposite direction.'

Galileo was the first to observe the above properties of virtual velocities in machines; John Bernoulli, however, first recognised the principle in all its breadth, and Varignon and several others verified it in almost all branches of statics. (Varignon, *Nouvelle Mécanique*, Paris 1725.) Lagrange, in his *Mécanique Analytique*, makes it the foundation of all mechanics, and deduces from it a uniform method of forming the equations of equilibrium and of motion for all possible systems of bodies. Fourier has demonstrated the principle from the property of the lever (*Jour. de l'École Polytech.* cahier 5); but Poinsot, in his admirable memoir (appended to his *Eléments de Statique*) on the equilibrium and on the motion of systems of bodies, has given perhaps the most complete analysis and demonstration of the principle.

Virtue. [ETHICS.]

Vis (Lat. *force* or *power*). In Mechanics, this word is synonymous with *force*. The term is used chiefly by the older writers, and is applied by them to divers kinds of forces or powers. Thus, *vis acceleratrix*, accelerating force; *vis inertiæ*, resistance; *vis motrix*, moving force, &c. *Vis mortua* and *vis viva* are terms which were used by Leibnitz and his followers; the former signifying a pressure, and the latter the force of a body in motion estimated by the distance to which the body goes. About the beginning of the last century, a keen dispute arose among mathematicians with respect to the manner in which the forces indicated by those terms ought to be estimated. It began with a prize essay by John Bernoulli on the *Investigation of the Laws of the Communication of Motion*, and was carried on for many years with great asperity. The question was, whether the force of a moving body is proportional to the square of the velocity, or to the velocity simply. No controversy (says Playfair) was ever carried on by more illustrious disputants: Maclaurin, Stirling, Desaguiliers, Jurin, Clarke, Mairan, were all engaged on the one side; and on the opposite were Bernoulli, Herman, Poleni, S'Gravesande, and Muschenbroek. The dispute was taken up as a point of national honour. Germany, Holland, and Italy declared for the *vis viva*; England stood firm for the old doctrine; and France was divided between the two opinions. ('Dissertation on the Progress

of Math. and Phys. Science,' *Ency. Brit.*) The difference in this case, as in most other disputes of a similar kind, arose from the parties not understanding each other. When the effect of a body in motion is measured by the distance to which it goes, before being brought to rest by a constant resistance, the effect is proportional to the square of the velocity; if measured by the time that elapses before the motion is destroyed by a resistance of uniform intensity, it is as the velocity simply. Both measures may be considered as correct, and they are not inconsistent when rightly understood. (Playfair's *Nat. Phil.* vol. i. p. 56.) The *vis viva*, considered as a power residing in a moving body, is now frequently called *kinetic* or *actual energy*. [FORCE; POTENTIAL ENERGY.]

Viscera (Lat.). The contents of the three great cavities of the body: the brain, e.g. is the viscus of the cranium, the heart one of the viscera of the thorax, and the stomach one of the abdominal viscera. The term is usually restricted to the organs of the thorax and abdomen; for the myelon is as much entitled to be called a viscus of the spinal canal, as the encephalon a viscus of the cranium. The hæmal arches of the cranial vertebræ have been called *visceral* in the embryo, and their interspaces the *visceral clefts*.

Viscin (Lat. viscum, *mistletoe*). A glutinous constituent of mistletoe, of certain berries, and of the middle bark of the holly,

Viscount. A title of honour; in its original signification, the delegate of a count (*vice-comes*), and applied to governors of towns and districts under the authority of that officer. In England, the appellation of *vice-comes*, or *viscounte*, in Norman French, was long used to designate the sheriff of a county (the vicegerent of the earl) before it became a title of peerage. It is the most modern of English honours in the latter sense; and was first conferred by letters patent on John Lord Beaumont, and the heirs male of his body, by Henry VI. in 1440. A viscount ranks between earl and baron.

Viscum (Lat.; Gr. ἰξός, *the mistletoe*). A genus of *Loranthaceæ*, of which *V. album*, the Mistletoe, is the only species to which any considerable interest attaches. This is a parasitical shrub, whose root, or what corresponds to a root, is firmly embedded in the substance of the tree on which it grows. The mode of attachment to the nourishing plant has been made the subject of an elaborate paper by Dr. John Harley, in the *Transactions of the Linnæan Society* (xxiv. p. 175). The roots of the mistletoe come in contact especially with the new wood inside the bark, where the descending sap is richest and most abundant, and are prolonged inwards in a direction parallel to that of the medullary rays. The cellular systems of the two plants thus come into contact, but no direct communication takes place between their vessels. As growth goes on, and annual rings of wood are added to the stock, similar rings are formed in the mistletoe, and so the woody layers of the two plants become coincident. The parasite slowly but surely involves the destruction of the branch upon which it grows.

The apple is the tree on which the Mistletoe grows most abundantly, and the orchards in Herefordshire are greatly infested with the parasite, which, however, has a value of its own, for it appears that upwards of one hundred tons of mistletoe are annually forwarded to London and other large towns from that county alone, for Christmas decorations. Next in frequency to the apple the mistletoe prefers the poplars, though it is not found on the Lombardy Poplar. It also infests hawthorns, limes, maples, and the mountain-ash. It has been found on the Cedar of Lebanon and on the larch, but rarely upon the oak. Undoubted instances of the latter have, however, been recently recorded—one at Eastnor Park, near Ledbury, Herefordshire, and another at Frampton-on-Severn, Gloucestershire. The magnificence of the oak on the one hand, and the rarity of the mistletoe on this tree on the other, are probable reasons for the greater reverence which was paid to the parasite when found on this tree.

Some botanists have proposed to separate *Viscum* from the *Loranthaceæ*, and to make it the type of a natural order, *Viscaceæ*.

Vishnu. In the Brahmanic Mythology, the god who with Brahma and Siva forms the Hindu Trimourttee. But this position is the growth of a later age. In the earliest Vedic literature, there are no indications of a Triad, the creative, preserving, and destroying power; 'and Vishnu, although named, has nothing in common with the Vishnu of the Romans; no allusion occurs to his avataras: his manifestation as Krishna, the favourite divinity of the lower classes, for some centuries at least, does not appear.' (Prof. H. H. Wilson in *Edinburgh Review*, Oct. 1860, p. 382.) By later writers he is regarded as a god who in his three strides is manifested in a threefold form, as Agin on earth, as Indra or Vayu in the atmosphere, and as the sun in heaven; but by some these three strides are interpreted as the rising, the culmination, and the setting of the sun. The place of Vishnu in the Vedas is examined at length by Dr. Muir, *Sanskrit Texts*, pt. iv. ch. ii. sec. 2.

Visible (Lat. visibilis, *that can be seen*). Objects are visible when they emit or reflect a sufficient quantity of light to make a sensible impression on the retina of the eye. According to Newton, colour is the proper object of sight; the visibility of an object must therefore depend on its transmitting to the eye rays of a different colour from those which proceed from the surrounding objects.

Vision (Lat. visio). In Optics, the faculty of seeing. Philosophers have disputed much respecting the means of vision, and its seat in the eye. The Platonists and Stoics held vision to be effected by the emission of rays out of the eyes. The Epicureans supposed vision to be performed by the emanation of images or corporeal species from objects

to the eye; and the Peripatetics differed in opinion from the Epicureans by supposing the species received by the eye to be incorporeal. Modern philosophers agree in referring the cause of vision to the impressions of light on the eye. [LIGHT.] In what manner the eye, or the particular part of it affected by the light, conveys to the brain the impression received from the luminous rays, is a question which philosophy has not yet solved.

Seat of Vision.—The retina of the eye, on which an inverted image of external objects is formed, is now generally regarded as the seat of vision. This opinion was long ago brought into doubt by the accidental discovery of Mariotte, that the base of the optic nerve is insensible to the rays of light, and consequently incapable of conveying to the brain the impression of vision. But this fact has since been explained by the discovery that the middle of the base of the optic nerve is occupied by an artery—the *arteria centralis retinæ*. This explanation has been confirmed by the experience of pathologists, who have observed cases in which the choroid coat, which is immediately below the retina, and all the vascular system of the eye, have remained sound, and yet blindness has ensued solely from an affection of the retina. On the other hand, vision, though disturbed, is not extinguished by any affection of the arteries, veins, or their combination with the pigment of the choroid, so long as the optic nerve and retina are sound.

Vision, Beatific. In Theology. The doctors of the church distinguish three manners of seeing or knowing God, which they call: (1) *Abstractive vision*; i. e. through the consideration of His attributes. (2) *Beatific* or *intuitive vision*; that which the faithful enjoy in heaven. (1 Cor. xiii. 12.) (3) The third kind of vision, or *comprehension*, is that which belongs only to God, who alone can know Himself as He is.

Visitation (Lat. visitatio). A festival of the Western Church, in honour of the visit of the Virgin Mary to Elizabeth. It is said to have been first instituted among the Franciscans by Saint Bonaventure, general of that order. It is celebrated on the 2nd of July.

VISITATION. In Ecclesiastical Law, the inspection by the bishop of the several parishes in his diocese; or by an archbishop of the dioceses in his province. By the ancient canon law, visitations were to be held once a year, and by the personal repairing of the ordinary to each parish; but the modern practice, which appears to have come gradually into use, owing to the extent of dioceses, is to summon the clergy from several parts to one convenient place. The times of episcopal visitations are now usually fixed in this country about Easter and Michaelmas. By Can. 60 of the English Church, such visitations for the purpose of confirmation must be triennial at least. The care of the ancient parochial institutions has by degrees devolved on the archdeacons, who hold periodical visitations for that purpose. They are bound to see that the offices of the church are duly administered; to keep account of the ornaments, vestments, &c. appertaining to the churches; to examine into the state of repair of parsonages, churchyards, &c.; and to receive presentments of excesses committed by ecclesiastical persons. Ecclesiastical corporations, such as conventual bodies, had usually their special visitors appointed by the founder; as is the case at present with colleges in our universities, hospitals, &c.

Visitation, Heraldic. These visitations seem to have been first instituted by King Henry V. in England; the purpose being to compel those who assumed coat armour to prove their right to do so before commissioners appointed by the crown. These visitations were usually held by the royal heralds entitled Clarencieux and Norroy (kings-at-arms), in different places within their respective provinces, once in every thirty years or thereabouts. The earliest of which the record remains in the library of the College of Arms is that of certain counties in 1528. The latest was held under a commission issued by James II. in 1686. These records are still referred to as of importance in establishing the claims of families to honours founded on pedigrees.

Vismia (after M. de Visme, of Lisbon). A genus of *Hypericaceæ*, chiefly found in the tropics of America, and consisting of trees or shrubs, with four-sided branches, opposite often glandular dotted entire leaves, and terminal panicles or cymes of yellow or greenish flowers. The yellow resinous juice common to the order exists in greater abundance in the plants belonging to this genus than in any of its congeners, and possesses more powerful purgative properties, resembling in that respect, and likewise in its appearance, the gamboge of the Old World—so much so, indeed, that that collected from *V. guianensis*, a species found in Guiana, Brazil, Surinam and Mexico, is called American Gamboge. Other species, however, such as the *V. sessiliflora* and *V. cayennensis* of Guiana, and the *V. micrantha* and *V. longifolia* of Brazil, also yield a similar resin, to which the name American Gamboge is equally applicable.

Visor or **Vizard** (Fr. visière, from Lat. video). A movable defence for the face, attached to the helmet in the middle ages. It generally turned on side pivots, sometimes on hinges at the forehead. It was worn in battle, unless the helm was put on over the bassinet, in which case the visor was removed.

Visual Angle. In Optics, the angle under which an object is seen, or the angle formed at the eye by the rays of light coming from the extremities of the object. *Visual rays* are the lines of light coming from an object to the eye.

Vitaceæ (Vitis, one of the genera). A natural order of hypogynous Exogens, nearly allied in character to *Celastraceæ* and *Rhamnaceæ*, but at once distinguished from the former by their stamens being opposite the petals, and from the latter by their valvate petals, and from both by their habit. They are mostly

tall climbers remarkable for the anomalous structure of their wood. Besides the great genus *Vitis*, which is now made to include all the species of *Cissus* and *Ampelopsis*, whether natives of the New or of the Old World, the order comprises only the small genus *Pterisanthes*, with a remarkable flat flower-stalk, and the slightly anomalous *Leea*, both confined to the Old World.

Vital Vessels. A name given by Schultz to certain vessels ramifying in all directions in plants, especially near the surface, and conveying latex, which that physiologist calls a vital fluid. The milk-vessels of spurges are vital vessels.

Vitellicle (Lat. vitellus, *yolk*, literally *a small calf*, as dim. of vitulus). The bag which is developed around the food-yolk, or that part of the yolk which has not been converted into the germ-mass and embryo. It is chiefly formed by a developement of the inner layer of the germinal membrane. The constricted part at which it is continued into the wall of the intestinal canal is called the *vitelline duct*. In man and mammalia the vitellicle is called the *umbilical vesicle*.

Vitellin. The albumen of the yolk of eggs.

Vitellus (Lat. *the yolk of an egg*). In Botany, the sac of the amnios in a thickened state, and forming a case, within which lies the embryo.

Vitiligo (Lat. vitulus, *a calf*). A disease of the skin, giving it a white appearance somewhat resembling that of calves.

Vitis (Lat. *a vine*). The genus *Vitis*, composed of a considerable number of species, including the well-known Grape-Vine, which is its most familiar and important representative, has a wide geographical range, but is principally found in the northern hemisphere, the majority of its species being natives of tropical and temperate Asia as far north as Japan, and also of North America. All the species are climbers, furnished with tendrils opposite the leaves, as in the Grape-Vine, the leaves of some being simple, and either undivided or variously lobed, and those of others compound. Their small greenish flowers are disposed in panicles set opposite the leaves, the Eastern species having complete flowers, and the Western usually incomplete ones, the two sexes very frequently on different plants.

The Grape-Vine is a native of the southern shores of the Caspian Sea and of Armenia. Associated with the fig, it follows the coast of the Black Sea, through Pontus, Mingrelia, and Colchis, and it has been found in the Crimea. From Asia, on the authority of Humboldt, the vine passed into Greece, and thence into Sicily. It was early carried into France by the Phocæans, when those Ionian colonists fled from the power of Cyrus, and founded the city of Marseilles, about 540 B.C. From Greece or from Sicily it could be easily introduced into Italy. The Romans planted it on the banks of the Rhine, and even, it is said, in Britain. Domitian restricted the cultivation of the vine, wishing rather to encourage that of grain; but in A.D. 278, permission to plant the vine was given by the emperor Probus. Being free from restriction, its cultivation throughout the provinces, including that of Britain, would of course extend. Vineyards are mentioned in the earliest Saxon charters, and these must have existed previously; for the combating invaders could neither have had the time, nor probably the skill, to make them. The monks in A.D. 1140 planted a vineyard at Edmondsbury in Suffolk, and William of Malmesbury says that vineyards were possessed by barons as well as by monks. [VINEYARD.]

There are various kinds of grapes, which grow wild and bear abundantly in North America, but they are very inferior to the varieties of *V. vinifera*. They belong to *V. Labrusca*, *V. cordifolia*, and others, and are called *fox-grapes* from their foxy perfume; their pulp is slimy and disagreeable.

Vitreous Copper-ore. A name for native sulphide of copper or COPPER GLANCE.

Vitreous Humour. The vitreous humour, so called from its glassy appearance, is the third or interior humour of the eye, filling a large portion of the eyeball, and greatly exceeding in quantity the aqueous and crystalline humours together. According to Sir D. Brewster, the refractive power of the vitreous humour is 1·3394. [OPTICS.]

Vitreous Silver-ore. Native sulphide of silver. [SILVER GLANCE.]

Vitrina (Lat. vitrum, *glass*). A genus of fresh-water Gastropods; so called from the extreme thinness and fragility of the shell, and its watery-green appearance. *Vitrina pellucida* and *Vitrina elongata* are natives of Great Britain.

Vitriol (Lat. vitrum; from the glassy character of its crystals). This term is applied by the old writers to crystallised sulphate of iron, or *green vitriol*; sulphate of copper and sulphate of zinc were afterwards called *blue vitriol* and *white vitriol*. [COPPER; IRON; ZINC.]

Vitriol, Oil of. The old name of sulphuric acid, which was originally obtained by distilling green vitriol. [SULPHUR.]

Vitriolite. A variety of sulphate of iron, in which part of the iron is replaced by copper. It occurs in the form of large stalactites and mammillary masses, in a cave near a mine of Copper Pyrites, in the interior of Turkey.

Vittæ (Lat. *fillets*). In Botany, the designation given to the narrow fistulæ or channels lodged in the coat of the fruit of umbellifers, and containing oil.

Vittie Vayr. The Tamul name under which perfumers sell the fibrous roots of the Khus-khus, Vetiver, or *Andropogon muricatus*, which contain an agreeable odorous oil. The *oil of lemon-grass*, and the *grass oil of Namur*, are obtained from the closely allied *Andropogon citratus* and *A. Calamus aromaticus*.

Vivace (Ital. *lively*). In Music, a term which, affixed to a movement, denotes that it is to be executed by the performer in a lively manner.

Viverridæ (Lat. viverra, *a ferret*). The name of a tribe of Carnivorous Mammals, of which the genus *Viverra* is the type. The characters of the Civet tribe are three premolars above, and four below; two tolerably large tuberculate molars above, one tuberculate and one sectorial molar below; the tongue beset with firm papillæ; claws more or less retracted: a large anal scent-gland and pouch.

Vivianite or **Blue Iron-earth.** A native hydrated phosphate of iron, composed of 28·75 per cent. of phosphoric acid, 42·27 protoxide of iron, and 28·98 water. It occurs in very long oblique prisms, frequently reniform and globular, also earthy and incrusting. The colour, which varies from pale green to indigo-blue, becomes darker on exposure. Named after the English mineralogist, J. G. Vivian.

Viviparous (Lat. vivus, *alive*, and pario, *I bring forth*). Those animals are so called which bring forth their young developed and alive, and commonly extricated from the egg coverings; as all the Mammalia, which were hence called Zootoka by Aristotle; many reptiles, as the viper or *viviper*; some fishes, and numerous invertebrate animals. In its restricted sense, the term signifies that mode of generation in which the chorion, or external tunic of the ovum, contracts a vascular adhesion with the uterus; and hence only the Placental Mammalia are truly viviparous, the rest being termed *ovo-viviparous*.

Vivisection (Lat. vivus, *alive*, and seco, *to cut*). A term used to denote physiological experiments upon living animals. This practice is more frequent in France than in England, and the only ground on which it can be defended is obviously that of the alleged needs of science. With the establishment or refutation of this plea, it must stand or fall. By those who altogether oppose it, the cruelty of such experiments is strongly insisted on. By those who justify it so far as it may appear absolutely necessary, it is answered that the sense of pain is far less intense in the lower animals than in man, and that the charge of gratuitous cruelty comes with a bad grace from any who uphold the custom of fox-hunting or stag-hunting; that even to an animal so highly organised as the horse, hunger is a source of greater uneasiness than that which is caused by a severe bodily injury; that the opening of the cavity of the peritoneum, for instance, is in man attended with serious danger, in dogs and other animals with little or none; and that this comparative insensibility is found in certain portions of the human race, as in Arabs contrasted with Europeans. The idea that vivisection is an indispensable condition for acquiring the highest surgical skill seems to be abandoned by all who have given their attention to this subject in this country; but the ascertainment of the effects of poisons (and this is strictly involved in the theory of vivisection) is, it is urged, often most necessary for purposes of justice, convictions having been obtained on the strength of experiments made on brute animals with the contents of the stomachs of persons alleged to have been murdered by poison. The necessity of the practice anatomically is defended on the authority of Sir Charles Bell, who states that he had recourse to experiments, although with great reluctance, when it seemed impossible to resolve a doubt by any other means. Thus, he says that 'it was necessary to know whether the phenomena exhibited on injuring the separate roots of the spinal nerves corresponded with what was suggested by their anatomy,' and that, after refraining long, he 'at last opened the spinal canal of a rabbit and cut the posterior roots of the nerves of the lower extremities,' &c. If, then, it be proved that vivisection is absolutely necessary for the general purposes of science, the practice, in so far as it is indispensably necessary, must be suffered to continue, and it may be remembered that in many cases the experiment destroys life more rapidly and with less pain than the clumsy strokes of the butcher, while in many others the pain may be mitigated, if not altogether prevented, by the use of chloroform. It may be safely laid down that 'the only fitting use of vivisection is for the purpose of proof and confirmation of a discovery otherwise arrived at, and that it is no more scientifically reasonable than it is morally justifiable to perform a number of experiments upon animals without a sufficient guide derived from previous investigation, and, in fact, without a clear and definite end in view.' Hence it follows 'that vivisections are not justifiable for the mere instruction of ordinary students; that they should be performed only by accomplished physiologists; that, when performed by them, they need be of a painful character only when the nervous system is the subject of investigation, and that even in this last case, in the present position of physiological science, vivisections are but very seldom necessary.' (*Westminster Review*, January 1866; Rowell, *On the Beneficent Distribution of the Sense of Pain*; *Report of the British Association*, 1863.)

Vizir (in Arabic *a porter*; and, by a singular metaphor, the title in various Oriental countries of a minister and councillor of state). The grand khalifs had their vizirs, who attained to the highest rank and consideration in their states, and were often more powerful than their masters; but after the creation of the new dignity of Emir-ul-omrah (commander of commanders), by Khalif Radhi, the older title lost much of its consideration. In Turkey, the councillors of state who sit in the divan, generally eight in number, are styled *vizirs*: and the chief among them *vizir azem*, rendered by us *grand vizir*, is the highest temporal dignitary in the empire.

Voandzeia (Voandzou, its Malagassy name). *V. subterranea* is the only known representative of this genus of *Leguminosæ*. It is a creeping annual, with long-stalked trifoliate leaves. The specific name, *subterranea*, has been given to it because its flower-stalks, like those of the *Arachis hypogæa*, bend down after flowering and increase in length, so that the

young pods are pushed into the earth, beneath which they ripen. It is a native of, and is extensively cultivated in many parts of Africa, from Bambarra and the coast of Guinea to Natal, its esculent pods and seeds forming a common article of food among the inhabitants of those countries. Although not indigenous to the western hemisphere, it is now commonly found in many parts of South America, such as Brazil and Surinam, whither it has been carried by the negro slaves, and has now become naturalised. The pods are sometimes called Bambarra ground-nuts; in Natal the natives call them Igiuhluba; while in Brazil they are known by the name of Mandubi d'Angola, showing their African origin, and in Surinam by that of Gobbe.

Vocative Case. In Grammar, the so-called case of exclamation or invocation. In strictness of speech it is not a case at all, and as having therefore no case ending, it represents simply the root of the word, on which the several cases are formed by means of pronominal suffixes.

Vochyaceæ (Vochysia, one of the genera). A natural order of hypogynous Exogens, consisting of trees or shrubs from tropical America, often of great beauty, and chiefly characterised by irregular flowers, four or five sepals, as many petals and stamens, or more frequently fewer, the stamens especially being often reduced to one, and always perigynous; and by a three-celled ovary, free or more or less inferior, the seeds usually without albumen. Little is known of the properties of these trees, beyond the hardness of the timber which some of them supply.

Voglite. A hydrated carbonate of uranium, lime and copper, which occurs in green scales having a pearly lustre, at the Elias Mine, near Joachimstahl, in Bohemia.

Voice (Lat. vox, vocis; Gr. ἔπος, for Ϝέπος [cf. ὄψ]; Sansc. vachas). The sound produced by the vibration of air emitted from the lungs of animals, which vibration is caused by an organ developed in the windpipe, called the *larynx*. Mammals, birds, and reptiles, are the only animals, which, according to the above definition, possess a voice; but many species of other classes produce peculiar sounds, by which the individuals are attracted to each other, or express their wants and feelings. A true organ of voice includes the lungs, bronchi, trachea, larynx, and mouth. The most essential parts are two vibratile chords bounding a slit-shaped aperture, called the *glottis*, and this may be situated at different parts of the air-tube in different animals; the portion of the tube between the glottis and the oral outlet being the true sonorous instrument. In mammals and reptiles the glottis is situated at the end of the wind-pipe, which communicates with the bronchial tubes, and consequently the whole trachea becomes, in this class, part of the vocal instrument. The organ of voice in reptiles consists of a simple larynx, without an epiglottis, the glottis being merely membranous, and not provided with fibrous vocal chords. Since neither fleshy movable lips nor soft palate exist in this class, the voice cannot undergo any further modification after its formation by the simple larynx. It consequently rarely rises beyond a hiss; and in the frog tribe, where the bones or gristles of the larynx are largest and most complicated, and the vibratile membrane of the glottis is best developed, the voice is only a more or less noisy croak.

In mammals, the air driven by the muscles of expiration from the lungs through the trachea strikes against the two vibratile *vocal chords*, which bound the sides of the glottis; and a voice is produced, varying in different animals, according to the power of regulating the degree of tensions of the chords, and according to the size and shape, and various complications of the laryngeal sacculi of the pharynx, of the tongue, and of the mouth and lips.

The superior organisation and mobility of the tongue and lips enables man to modify his vocal sounds so as to render them articulate, and adapted to express the ideas which it is his peculiar privilege to form. (Max Müller, *Lectures on Language*, second series, iii.) Although some quadrupeds possess the imitative faculty, and can be taught to do certain tricks, it would seem that the physical condition of their vocal organs is an insuperable impediment to their imitation of the human speech.

The sacculi or membranous pouches which communicate with the larynx in the gorilla, chimpanzee, orang, and most other quadrumanous animals, together with their thicker and more confined tongues and less flexible lips, are assumed to constitute the impediments to speech in them; but it may be doubted whether they have the imitative faculty for sounds possessed by the parrot or starling; and the absence of any voluntary application of their vocal organs for the purpose of speech is accounted for by presuming that they have nothing to say.

In birds, which possess the most diversified and complicated organ of voice, combined in some species with a high degree of imitativeness, instances are not uncommon, especially in the parrot and crow tribe, of an acquired power of forming articulate sounds superadded to the ordinary voice.

Voided. In Heraldry, a term applied to any ordinary when it is pierced through, so that the field which it overlies appears, leaving only the outer edge of the ordinary, e.g. a saltier, chevron, &c. voided. Voided per cross, when pierced with an opening in the shape of a cross, through which the field in like manner appears.

Voigtite. A mineral with nearly the same composition as Biotite, which replaces Mica in the granite of the western part of Ehrenberg, near Ilmenau.

Voire Dire (Nor. Fr. *to speak the truth*). In Law, according to ancient practice, an objection to the competency of a witness, in a trial at common law, was properly taken on a

preliminary examination, in which the witness was sworn *to speak the truth*, and then examined touching his interest in the subject-matter; but witnesses are not now incompetent on the ground of interest.

Volatile Alkali. [AMMONIA.]

Volatile Oils. [ESSENTIAL OILS.]

Volborthite. A native vanadiate of copper, which occurs in small tabular crystals of an olive-green or grey colour, at Sissersk and Nijni Tagulisk in the Urals. Named after Dr. Volborth.

Volcanic Garnet. A Mineralogical synonym of Pyroxene (Augite) from its occurrence in volcanic rocks. The name has, also, been given to Vesuvian, or the variety of Idocrase found at Vesuvius. [IDOCRASE; VESUVIAN.]

Volcanic Glass. A name commonly given to Obsidian from its glassy nature.

Volcanite or **Selensulphur.** A compound of selenium and sulphur, which is found on Vulcano, one of the Lipari Islands, and also in Hawaii.

Volcano (Lat. Vulcanus, the god of fire; a name akin to the Sanscrit ulkâ, *a firebrand*). The name given to a part of the earth's surface, whence vapour, mud, ashes, or melted rocks issue from a hollow depression in a conical hill or mountain. Generally the material already erupted, of whatever kind, has formed the hill, or where the point of eruption was already at a high level, has added the conical summit. [EARTHQUAKES.]

The geographical extent of volcanic districts is very considerable. It is true that the points of eruption and the movements of great earthquakes are confined to certain regions in which the volcanic vents are distributed at intervals, and most commonly in a linear direction; but there is evidence that similar powers are at work continuously throughout the intermediate spaces, for the ground is from time to time convulsed, gases and vapours are disengaged, and hot springs issue, the waters of which are very commonly impregnated with the same mineral matters which are discharged by the eruption of the volcano. [SPRING.]

There are also abundant proofs of the existence of volcanic fires under various parts of the bed of the ocean, where their effects, though at present unseen and unknown, are probably destined to become evident at some future but very remote period.

The substances thrown out by volcanoes are chiefly earthy and alkaline bodies in a state of fusion, together with red-hot and melted rock, stones, cinders, ashes, steam, and various gases; and although they differ very materially in the quantity of ejected matter, their products so generally agree in quality that they may doubtless be all referred to the operations of one cause. What that cause is, is a question not yet satisfactorily answered; we must, however, notice the perpetuity, as it may almost be called, of some active volcanoes—volcanoes which have continued to burn and throw out lava and cinders, not only for years, but for successive ages. The lava in the crater of Stromboli has been in a state of ignition for 2,000 years; so that there has here been a constant accession of heat, if not renovation of fuel.

We have ample evidence of the connection of earthquakes with volcanoes; and all great eruptions have commonly been preceded by violent convulsions, which have ceased upon the bursting forth of the volcanic fires, as if the pent-up matters had found a vent. All this shows the cause of the eruption to be deep below the surface. There is, further, a manifest connection between volcanic vents situated at great distances from each other. Such a connection has been traced not only between Vesuvius and Etna, but between these two volcanoes and those of the Greek islands at the distance of a thousand miles. Some of the volcanoes of the Andes appear to alternate in their eruptions, though at great distances from each other.

When lava is examined near the vent whence it issues, it is usually a semifluid mass about the consistence of honey. It soon cools externally, and its surface becomes rough and irregular; but, being a very bad conductor of heat, the interior remains red-hot long after the surface has cooled.

The quantity of matter which has been thrown to the surface by volcanic agencies during the historical period is very enormous, and may serve to give an idea of their influence in modifying the surface of the globe, when such powers are considered in reference to great periods of time. In illustration of this point we may select the volcanoes of Iceland, because our details respecting them are well authenticated; though it must be recollected that they fall into insignificance when compared with what has happened in some of those districts of Asia and South America which are ravaged by subterranean fires.

Iceland itself is little else than a mass of lava; and so intense is the energy of volcanic action in that region, that some eruptions of Hecla have lasted six years without ceasing. In this island, too, the volcanic vents are often in alternate action, one serving, as it were, for a time as a safety-valve to the rest; and when, as is often the case, new cones are thrown up, they generally take a linear direction. In 1783, a new island was thrown up off the coast, consisting of high cliffs; and with such an ejection of pumice, that the ocean was covered to the distance of 150 miles, and ships impeded in their course by the shoals of floating stones. Before a year had elapsed, however, the sea resumed her ancient domain, the volcanic cliffs had disappeared, and nothing was left but a rocky reef from five to thirty fathoms under water. In June, the Skaptar-Jokul, 200 miles distant from the new isles, threw out a torrent of lava, which in the first place flowed down into the river Skaptaa, and completely dried it up; its channel was between high rocks, and was in some places 400 to 600 feet deep and 200 broad. Not only did the lava fill these great defiles up to the brink, but overflowed the adjacent

country and filled up a deep lake. There was then a short intermission in the eruption; but in a few days it was resumed, and the newly ejected lava flowed rapidly over the surface of the first, and, damming up numerous streams, deluged the neighbouring country with water, and destroyed several villages; after flowing for several days, it was precipitated down a tremendous cataract, and filled the cavity which the waterfall had been hollowing out for ages. Afterwards the lava took a new direction, and discharged itself into the bed of another river (the Hyversfliot): the lava accumulated to a great depth, and coming to the plains spread out into broad lakes of fire, some of which were from twelve to fifteen miles wide, and 100 feet deep. When the fiery lake which filled the valley of the Skaptaa had been augmented by new supplies, the lava flowed up the course of the river to the foot of the hills where it rises. This eruption continued two years; and when Mr. Paulson visited it eleven years after (in 1794), the lava was still smoking, and its vents were filled with hot water. Although the population of Iceland did not exceed 50,000, twenty villages were destroyed, exclusive of those inundated by water; and all the cattle of the district, with more than 9,000 human beings, perished.

We have quoted the narrative of this eruption as giving, upon good authority, some notion of the extraordinary volume of melted matter produced. Of the two branches of lava (and they flowed nearly in opposite directions), one was fifty and the other forty miles in length; the extreme breadth of one branch was from twelve to fifteen, and of the other about seven miles. The ordinary height of the currents was about 100 feet; but in deep ravines and defiles they sometimes attained 600 feet.

But there are some phenomena connected with volcanic action which seem to be caused by yet more extraordinary agents than those already noticed, viz. their *great projectile and explosive force*. From the era of the discovery of the New World to the middle of the last century, the great volcanic district of Mexico had remained undisturbed. It is an elevated tract of broken ground, between 2,000 and 3,000 feet above the level of the sea, and bounded by hills of ancient igneous origin. It was occupied by fields of sugar-cane and indigo, and watered by two brooks. In June 1759, alarming sounds and earthquakes preceded the bursting forth of flame from the ground, and fragments of red-hot rocks were thrown to prodigious heights. A great chasm was formed, from which six volcanic cones were thrown up, the least of which was 300 feet high; and Jorullo, the central volcano, was brought by successive accumulations of erupted material to a height of 1,000 feet above the level of the surrounding country. It sent forth streams of basaltic lava, including fragments of granitic rocks, and its eruptions did not cease till 1760. Humboldt, visiting the country forty years afterwards, saw round the base of the cones, and spreading from them over an extent of four square miles, a convex mass of matter, between 500 and 600 feet high, gradually sloping in all directions towards the plains, and still so hot that he lighted a cigar in one of its fissures. It was covered with thousands of little mounds, which emitted steam and sulphuric acid. The two small rivers lost themselves below the east extremity of the plain, and reappeared as hot springs at its western limit. Humboldt attributed the convexity of the plain to inflation from below, supposing the ground for the extent of four square miles to have been puffed up like a bladder to the elevation of 550 feet in the highest part; but of this there seems no good evidence. A subsequent eruption of Jorullo happened in 1819, and it is much to be regretted that no European travellers have since visited the spot. It is known, however, that about the time of this eruption ashes fell in Guanaxuato, 140 miles from Jorullo, in such quantity as to lie six inches deep in the street; and the tower of the cathedral was thrown down by an accompanying earthquake.

Instances of similar volcanic action in the sea are not uncommon. In 1811 a volcano forced its way from beneath the sea off the island of St. Michael, one of the Azores, forming a crater above the water a mile in circumference, and about 300 feet high. In the middle of the seventeenth century an island was thrown up among the Hebrides, which in a month again disappeared. In July 1731, a volcano rose in the sea between the island of Pantellaria and the coast of Sicily, forming a crater 240 feet diameter and twenty feet above water. In 1866, a small group of islands rose out of deep water in the bay of Santorin, during a considerable eruption of lava. Many shoals are, no doubt, of volcanic origin.

The Pacific Ocean, in equatorial latitudes, seems to be one vast theatre of igneous action; and its innumerable archipelagoes, such as the New Hebrides, Friendly Islands, and Georgian Isles, are all volcanic, with active vents here and there interspersed. Of such a formation Owhyhee (Hawaii) is a magnificent example. The island is triangular in shape, the sides measuring respectively 100 miles, 88 miles, and 76 miles. Its whole area (4,000 square miles) is composed of lava. It contains three lofty volcanic summits, Mount (or Mauna) Loa, 13,760 ft., being the principal, and the others being about 14,000 ft. and 10,000 ft. respectively. The land slopes gently from the coast to the foot of the great cones, as in Etna, and thus their altitude is not observed. The area of the base of the great cone is, however, larger than the whole area covered with volcanic products in the neighbourhood of Etna. The crater of this great cone, Kilauea, is by far the largest in the globe, and is not surrounded by a cone of ashes as is elsewhere the case. The traveller rises on the slope of the dome (averaging only 6° 30′) to the edge of a pit, and looks down a depth (which before the last eruption in 1855 was about a thousand feet)

to a plain of bare naked lava more than two miles across—the bottom of a vast amphitheatre nearly eight miles in circuit. Within this amphitheatre is the great pit-crater itself. It is 16,000 ft. in length, and averages 7,500 ft. across. It includes an area of four square miles. When last described, there was in one part of it a throat or gullet full of boiling lava measuring 1,500 ft. by 1,000 ft. The lava is remarkably fluid, and rises occasionally to a great height, filling the whole area of the pit-crater to the height of many hundred feet. It generally finds a vent in the side of the mountain, without rising nearly to the top of the crater. Many great eruptions have taken place from this volcano within the present century. Those of 1823, 1832, 1840, and 1855, were the chief. They were all unaccompanied by earthquakes or ashes. As described many years ago by the Rev. Mr. Ellis, the gullet was even larger than it has been lately.

We may conclude this part of our subject with a brief notice of one other volcano, viz. that of Tomboroo in the island of Sumbawa, described by Sir S. Raffles. It began on April 5, 1815, when a Malay prow, while at sea, on the 11th, was enveloped in utter darkness; and the commander, afterwards passing the Tomboroo mountain, at the distance of five miles, observed that the lower part appeared in flames, while the upper portion was concealed in clouds. Upon landing to procure water, he found the ground three feet deep in ashes, and several large vessels thrown on shore by the concussions of the sea.

At the commencement of the explosion the commander of the E.I.C. cruiser Benares, which was at Macassar, supposed that there was an engagement of pirates somewhere in the neighbourhood, so closely did the reports resemble those of cannon. On the 11th, the ship was again shaken, as it was thought, by the discharge of cannon. At eight A.M. on the 12th, the face of the heavens to the south and west had assumed a dingy aspect, and it became darker than it had been at sunrise. A dusky red appearance gradually spread over the heavens; and by ten it was so dark that a ship could hardly be seen a mile off. By eleven, the whole heaven was obscured, except a small space in the east horizon, whence the wind came. The ashes now fell in showers, and the appearances were most alarming. By noon the light which had lingered in the horizon disappeared. At half-past seven the next morning there was a glimmering of light, and objects could just be perceived on deck. When day returned, the appearance of the ship was most singular; every part being covered with grey dust, which lay in heaps of a foot deep on many parts of the deck. On the 13th, the vessel left Macassar, and made Sumbawa on the 18th. Approaching the coast, she encountered an immense quantity of pumice, with numerous burnt trees and logs; and the anchorage was greatly altered, for the vessel grounded on a bank where there had previously been six fathoms water. The shores were entirely covered with ashes and cinders ejected from Tomboroo, forty miles distant. The explosions were terrific; and there is evidence of their having been heard in Sumatra, upwards of 900 nautical miles from Sumbawa. Lieut. Phillips, who was despatched to afford relief to the perishing inhabitants, learned from the rajah of Saugar that, on April 10, the fire and flame raged with exhaustless fury, till all became dark from the quantity of falling matter. At this time stones fell very thick, from the size of a walnut up to that of two fists; and the sea, rising twelve feet above its usual levels, swept away all within its reach, including some thousands of the inhabitants.

Of the eruptions of Vesuvius, we have many excellent narratives. From the remotest periods of which we have any tradition down to the Christian era, this volcano was in a state of inactivity; nor were there any other indications of its volcanic character than such as were deducible from the resemblance in its structure to other volcanoes, like the extinct volcanoes, as they are called, of the present day. Pliny does not include it in his list of active vents, but Strabo adverts to its volcanic aspect. Its form was then very different from that which it now exhibits, and the sides were covered with fertile fields. At its base were the populous cities of Herculaneum and Pompeii. The first symptom of renewed activity was in A.D. 63, when an earthquake shook the neighbourhood; and in August 79, it erupted lava. The elder Pliny, who commanded the Roman fleet, then stationed at Misenum, in his anxiety to get a near view of the phenomena, was suffocated by the exhalations. His nephew has given a graphic description of the scene, but has inexplicably passed over the destruction of Herculaneum and Pompeii. Indeed, so vague are the narratives long subsequent to that event, that if those buried cities had not been discovered, the accounts of their tragical end would probably have been regarded as fabulous. Tacitus, the friend and contemporary of Pliny, merely says that cities were destroyed; and the first writer who distinctly names them is Dion Cassius, who flourished about a century and a half after Pliny. We have some interesting historical facts, showing that Pompeii and Herculaneum were destroyed by ashes and mud, and not by red-hot lava. When the amphitheatre at Herculaneum was first cleared out, ashes were arranged on the steps just as snow would lie if it had fallen there: the whole superincumbent mass was from 70 to 112 feet deep. The foundation of both cities is ancient lava. Herculaneum, although buried to a much greater depth than Pompeii, was discovered first by the accidental circumstance of a well being sunk in 1713, which came directly down upon the theatre, where the statues of Cleopatra and of Hercules were soon discovered.

There are many instances of rocks of decided volcanic origin, i.e. extinct volcanic vents, in districts where all other trace of activity except

that which is shown by hot and mineral springs has been lost since the earliest historical times. Such are the Vivarais and Auvergne in Central France, and the district of Eifel, near Coblentz, on the Rhine. [BASALT; IGNEOUS ROCKS.]

Volcanoes, Mud. These curious phenomena, common in districts far removed from active volcanoes, but not unknown in their immediate vicinity, are the result of an inferior volcanic activity, which may be due either to an inchoate or to an effete and expiring volcanic energy; but our knowledge of their causes is still very incomplete.

In Europe, the most extensive phenomena of this kind have occurred in the eastern part of the Crimea, between the extremity of the Caucasus and the commencement of the Carpathians; on the southern flanks of the Caucasus, near Teflis; and in the delta of the Kuban, an important stream entering the Black Sea at its junction with the sea of Aral. On the promontory of Kertch, in the Crimea, very large masses of semifluid mud have been erupted, for the most part cold, though sometimes near the boiling point of water, and these have formed hills some hundred feet high and many miles in length. On the slopes of Mount Etna, and near Girgenti in Sicily, as well as on the northern slopes of the Apennines near Modena, similar phenomena have occurred, though on a smaller scale. In Java and in Mexico they are very grand in their developement, and in California on the eastern side of the mountains there are extensive tracts of the same general nature. They abound in Trinidad, and exist in Iceland. In almost every case the phenomena are the same: mud more or less liquid, bitumen in greater or less quantity, sulphurous vapours and eruptions, occasionally of solid mud or lignite.

It is probable that the conditions which, in most districts where hot springs occur, suffice only to bring clear water to the surface, are capable, under certain modifications, of lifting up mud and other products.

Volgerite. A mineral resulting from the alteration of Cervantite, and consisting of 60·3 per cent. of antimony, 18·8 oxygen, and 21 water. It occurs as a white powder or crust, and is named after Volger, by whom it was analysed.

Volition (from Lat. volo, Gr. βούλομαι, *to will*). The power of exercising the will. It is localised in the cerebral hemispheres, and probably to a certain extent in the *myelon*. [WILL, FREEDOM OF THE.]

Völknerite. A hydrated aluminate of magnesia, occurring in white, six-sided prisms with a pearly lustre, at the mines of Schischimskaja Gova, in the Ural. It is named after Völkner, a director of mines.

Volsunga Saga. The saga relating the story of SIGURDR, which is reproduced under different names, and with certain modifications, in the NIBELUNGEN LIED.

Volta-electric Induction. The term *induction*, as applied to frictional electricity, has been explained in art. ELECTRICITY. Not only is induction produced in neighbouring bodies by the presence of static electricity (electrostatic induction), but an induced current is also momentarily developed in adjacent metallic bodies by the action of dynamic electricity (electro-dynamic or volta-electric induction).

This important phenomenon was discovered by Faraday in 1831, and one of his fundamental experiments was made in the following manner: A long copper wire was wound in the form of a spiral round a cylinder of wood; a similar, but perfectly separate spiral, was then wound upon the same rod, the coils of each being interposed and close to each other, but nowhere in contact; the extremes of one of the wires were then connected with a galvanometer, and those of the other with a voltaic battery. At the moment of making contact with the battery, as well as of breaking it, the deflection of the galvanometer indicated a current of induced electricity in the proximate spiral; but in the interval, i.e. whilst the current of electricity was continuing quietly to flow, no deflection took place. The induced current was found to be in a direction opposed to the battery current upon making the contact, and in the contrary direction upon breaking it. The current from the battery is known by the name of the *primary* current, while the current induced in the adjacent wire is termed *secondary*, and the wires are in like manner called *primary* and *secondary coils*.

The first induced currents obtained in the manner described were only just sensible; but of late years the effects have been so exalted, that induction currents now furnish a most powerful source of electricity, and their luminous and physiological effects approach the nature, and, on a small scale, almost rival the grandeur, of a lightning discharge.

By the introduction of a soft iron core into the primary coil, the original effects have been much intensified; for, on the passage of the current, the iron becomes a magnet, and adds its own induction [MAGNETO-ELECTRIC INDUCTION] to that of the electric current. Further increase of power has resulted from carefully insulating the secondary coil, and greatly increasing its length and the number of its convolutions round the primary. Finally, by introducing into the primary current a mechanical means for rapidly making and breaking the circuit, and into the secondary circuit what is termed a *condenser* (consisting of a number of alternate sheets of tinfoil and varnished paper, in principle the same as a Leyden jar), a torrent of sparks, in some instruments as much as fifteen inches long, can be obtained from the terminals of the secondary coil. Some of the greatest improvements in the construction of *induction coils* or *inductoria*, as these instruments are now called, have been made by Ruhmkorff of Paris, and hence these instruments frequently go by the name of *Ruhmkorff's coils*.

Although the induced current lasts but momentarily, yet during its existence it can develope a second induced current in an adjoining wire, whose ends are connected. This second closed circuit can likewise develope a third in-

duced current in another adjacent wire, and thus induced currents of different *orders* and gradually diminishing intensity can be produced. These minor currents were discovered by Henry, and are termed currents of the third, fourth, &c. order, or tertiary and quaternary currents; they move alternately, in opposite directions.

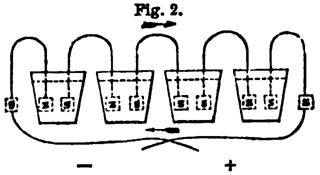
Voltaic Battery. The combination of a number of elements or cells, each of which generates a certain quantity of dynamic or voltaic electricity.

The first electro-motive apparatus was constructed by Volta in 1800, who arranged a series of discs of silver or copper, zinc, and then flannel or pasteboard soaked in salt-water or dilute acid. These discs were alternately laid on each other until a pile of them had been built up, A B, fig. 1. To the metallic ends of this pile, wires, *w w'*, were connected. With a

Fig. 1.

sufficient number of alternations, forty or more, a shock was felt on joining the wires, or the gold leaves of an electroscope could be diverged. The quantity of electricity set in motion by this means is small, but its tension, or power of overcoming resistances, is high; hence in character it is somewhat like frictional electricity, but differing from it in that its origin is directly chemical, and not mechanical action. It was soon conjectured, that if a perfectly dry pile could be constructed, the chemical theory of the battery would be disproved, and Volta's contact theory confirmed. [VOLTAIC ELECTRICITY.] To decide this point, De Luc formed a pile of pieces of zinc, silver, and writing paper, and with some hundreds of these discs succeeded in obtaining, apparently without chemical action, a source of weak electrical power, which by its attraction and repulsion could be made to produce a continuous mechanical motion. But though this combination will remain active for some years, its power gradually sinks from the oxidation of the zinc. Thus chemical action does even here take place, and arises from the moisture present in ordinary paper, for if the paper discs be previously well dried no manifestation of electricity occurs. Zamboni, in 1812, constructed a so-called *dry pile* of discs of paper rubbed over on one side with peroxide of manganese, and coated on the other with thin tin or silver leaf, generally sold attached to the paper. From its simplicity, durability, and comparatively high electrical power, this is one of the best dry piles.

Fig. 2.



But even the best of these piles are but feeble, and the inconvenience of their arrangement soon led Volta to the improved modification represented in the following diagram, fig. 2, which he called the *crown of cups* (couronne des tasses). The flannel or paper in the pile is rejected, and in its place a cup of dilute acid is substituted; in each of these cups is a plate of zinc and one of silver, so connected that each silver and zinc plate is in metallic communication, though in separate vessels: the arrangement being zinc, acid, silver; zinc, acid, silver, &c. The direction of the electric current is the same as in the simple circle, viz. from the zinc through the liquid to the silver [VOLTAIC ELECTRICITY, fig. 2]; but in this form of the apparatus, for the mere convenience of carrying on the series, the conducting wire connected with the first zinc plate has a supernumerary silver one attached to it, while the wire with the last silver plate has a supernumerary zinc plate. Hence much confusion has arisen in regard to the direction of the current in these cases, in consequence of calling what is here the silver extreme the *negative pole*, and the zinc extreme the *positive pole*; whereas it is in fact the reverse, and the circulation of the current goes on through the electrodes precisely as in the simple circle.

The cumbersome form of Volta's couronne des tasses was in a measure removed by Cruickshank, who, acting upon the idea of Volta's pile, soldered together the plates of zinc and copper, and used the metals themselves as the partitions of a long water-tight trough into which they were cemented, so as to leave intervening spaces, as shown in fig. 3. When required for action, dilute acid, or a saline solution, is poured into the cells thus formed. It was with a series of troughs of this kind, some of which are still preserved in the Royal Institution, that Davy made his memorable electro-chemical discoveries. Some inconveniences found in the last form of battery were removed by Dr. Babington, who devised the arrangement shown in the annexed cut, fig. 4. The plates of zinc and copper are here attached, in proper order and connection, to a piece of dry wood, so that they may at once be plunged into the exciting liquid contained in the cells of a porcelain trough over which they are suspended.

Fig. 3.

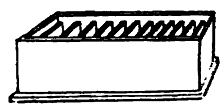
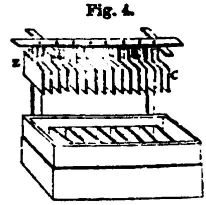


Fig. 4.



An important modification, as regards the arrangement of the plates of fig. 4, introduced by Dr. Wollaston, is represented in fig. 5; the copper plate C, instead of being single, is doubled over the zinc plate Z, actual contact being prevented by wooden cylinders placed between them. In this way much of the elec-

tricity lost in the preceding arrangements is brought into circulation.

In these arrangements, however, the electrical power is liable to fluctuation; and, after a time, various causes induce such a falling off in its evolution as to render them inconvenient, or even useless, where continuous or regular action is required. One of the reasons of this diminution of power (besides the saturation of the acid by the zinc dissolved during the action of the battery) is a *local action* on the zinc by which it becomes rapidly destroyed, even when the circuit is broken. This is due to the impurity of the metal, and can be prevented by *amalgamating* the zinc, a process best effected by dipping the plate in dilute sulphuric acid, and then rubbing it over with mercury. But, even after amalgamation, particles of the zinc are precipitated upon the copper plate, and, further, the hydrogen liberated at the zinc plate is carried over to the copper, and adheres as a film on the surface of the plate. Both these actions destroy the negative character of the copper, for hydrogen has electrical properties similar to zinc. The latter process, termed *polarisation*, is removed by an arrangement proposed by Smee. In this battery (fig. 6), the negative plate P is of silver, and is coated with a deposit of finely divided platinum: on each side of this plate are fixed two plates of amalgamated zinc Z Z′, and the whole is united to a clamp, and plunged in dilute sulphuric acid, about 1 of acid to 7 of water. The hydrogen, as it reaches the platinised silver, cannot adhere to the rough surface, and is given off with a hissing noise. The simplicity and power of this battery have brought it into frequent and extensive use.

Fig. 5.

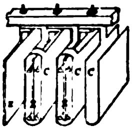
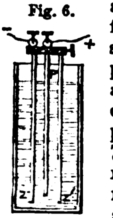
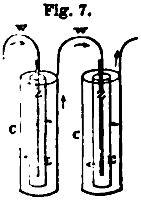


Fig. 6.



The most valuable improvement in the voltaic battery was suggested by Daniell, whose method obviates, to a great extent, both the inconveniences before mentioned, and by remaining in action for a long period well merits its name of *constant battery*. Fig. 7 shows the construction and arrangement of two Daniell cells. C C are cylindrical vessels of copper closed at the lower end; E E similar smaller cylinders of porous earthenware; Z Z are rods of amalgamated zinc, which are connected by the wires W W with the next copper cylinder, and so on in succession. The porous tubes are filled with dilute sulphuric acid (about 1 part of acid to 8 of water); and the copper cylinders are filled with a strong solution of sulphate of copper. The acid in the generating cells is thus separated from the solution of sulphate of copper; but the porosity of the tubes allows of their becoming so far imbued with the acid liquid as to admit of the passage of electricity, the current being in the direction of the darts. In this manner the sulphate of zinc is prevented from mixing with the sulphate of copper, and thus there can be no precipitation of zinc upon the copper. At the same time the hydrogen evolved in the copper cells or cylinders tends to reduce the oxide of copper, and continuously to throw down a film of metallic copper, with which the cells ultimately become lined. In proportion as the sulphate of copper is decomposed, fresh portions of that salt are added, and for this purpose there is a perforated receptacle or colander in the upper part of the copper cell, which is kept filled with crystals of sulphate of copper, the only change necessary being an occasional renewal of the dilute acid in the porous cells. This battery is superior to any as yet described, and in some respects has not been surpassed. The absence of fumes from it, its constancy and power, cause it to be in many cases invaluable for manufacturing use and scientific research.

Fig. 7.



One of the most powerful batteries yet constructed is that devised by Grove, upon the same principle as Daniell's. A rectangular plate of amalgamated zinc, Z Z′, is bent in the shape shown, in section, in fig. 8. The plate is immersed in dilute sulphuric acid, 1 of acid to 6 of water, contained in a porcelain vessel, A B. Within the bend of the zinc is a porous cell, filled with strong nitric acid, plunged in which is a plate of platinum, P. The hydrogen, before it can reach the platinum in the inner cell, is taken up by the nitric acid, and, decomposing it, liberates irritating red fumes of nitrous acid gas, the greatest objection to this battery. The power of this battery is greater than that of Daniell's, and from its compact arrangement is generally used in England for lecture illustration. On the Continent a modification of Grove's battery, proposed by Bunsen, is more frequently employed. In Bunsen's battery the hard coke obtained from gas retorts replaces the platinum in the porous cell, the other parts remaining the same. But, though the original expense of the battery is thus lowered, yet there are many objections to the substitution of coke, and hence we may consider Grove's battery to be for most purposes the best arrangement yet made.

Fig. 8.

The relative value of the different forms of voltaic battery has been variously estimated. The following tables are taken from Napier's *Manual of Electro-metallurgy*. The *electromotive force* or *strength* was compared by finding the amount of copper deposited from a solution of the sulphate during the same time. Only one pair of plates, exposing in each case the same surface of zinc, constituted the battery; the time in action was one hour.

	grains
Grove's battery deposited .	104
Daniell's " " . .	33
Smee's " " . .	22
Wollaston's " " . .	18

Hence Grove's battery has the highest electromotive force; but comparing the *constancy*, it will be seen in the next table that Daniell's has the advantage. Here the time was prolonged, the quantity of copper deposited being ascertained at the end of each hour.

In action	One Hour	Three Hours	Five Hours	Seven Hours
	grains	grains	grains	grains
Grove's battery .	104	66	54	45
Daniell's " .	33	34	32	31
Smee's " .	22	14	12	10
Wollaston's " .	18	15	11	10

The *time* and *cost* of depositing one pound of copper by these different batteries, found by actual experiment, is given in the next table. A single pair of large flat plates was used in each case.

	Time.	Cost.	
	hours	*s.*	*d.*
Grove's battery	19½	2	8
Daniell's "	49	3	4
Smee's "	147	2	4
Wollaston's "	151	2	3

Voltaic Electricity. This term is used to denote the phenomena resulting from the evolution of a current of electricity by chemical action. About 1790 Galvani noticed that the limb of a frog was convulsed if it happened to be touched by the extremities of two dissimilar metals when in contact at the other end. [GALVANISM.] Both Galvani and Volta thought, and rightly, that the convulsion of the frog was due to electricity; but both were wrong in their theoretical explanation of the source of this electricity. It is not the frog alone, as Galvani thought, nor the contact of dissimilar metals alone, as Volta supposed, that gives rise to the electric current, the physiological effect of which was observed by Galvani. It has now been abundantly proved by Faraday, that the source of voltaic electricity is a difference of chemical action, taking place between the intervening liquid and one or other of the metals.

Whenever substances act chemically upon each other, their normal electrical states are supposed to be disturbed; but the electricity thus evolved is, in ordinary cases, so lost and dissipated, as to escape observation. It may, however, be rendered manifest by the following simple arrangements: When a plate of pure zinc, or common zinc rubbed over or amalgamated with mercury, is dipped into a glass of very dilute sulphuric acid, little or no action is observed; nor does anything happen when a similar plate of silver is placed in the same cup of acid, provided the metals be kept apart from each other. But if, as in the annexed figure, the zinc and silver be brought into contact, at their extremities out of the liquid, the water is decomposed; its oxygen combines with the zinc to form oxide of zinc, which is dissolved by the acid; and its hydrogen passes over to the surface of the silver, where it collects, and ultimately escapes in gaseous globules. These phenomena are further connected with the production of a continuous current of electricity passing *from* the zinc across the water *to* the silver, and again from the silver, by metallic contact, to the zinc, in the direction represented by the darts. It is not necessary that the metals should be connected exactly as represented in the above diagram; but it *is* necessary, in order to establish the continuous electric current, that they should be somewhere in contact, or joined by a conductor such as a metallic wire. By modifying the preceding arrangement, so that the metallic contact between the plates be made at some distance from the vessel, as at the point A, fig. 2, the electric current takes the same direction, travelling through the liquid *from* the zinc or generating plate Z *to* the conducting plate S, and through the wires B and C back again to Z, as shown by the darts. Here again Z is oxidised and dissolved, and hydrogen is liberated upon S; but the moment that the circuit is broken, by parting the wires at A, these actions cease, because the electric current ceases to flow. Such an arrangement as that here represented is termed a voltaic *couple* or element. When the metals are disconnected at A, the circuit is said to be open; when connected, it is termed a *closed circuit*.

Fig. 1.

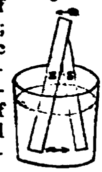
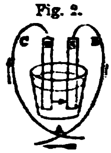


Fig. 2.



It is evident that if the production of a voltaic current depends upon a difference of chemical action on two substances, many other bodies in which this difference exists, besides zinc and silver, may be employed: for instance, for the zinc, tin or iron may be used; and for the silver, copper, platinum, and a hard kind of coke. Other liquids may also be substituted for the dilute sulphuric acid; the only necessary conditions for the generation of a voltaic current being that one *more* than the other of the two plates in each couple shall be chemically attacked by the interposed liquid, which, as well as the plates themselves, must be able in some degree to conduct electricity. The direction of the current is the same in all cases, viz. *from* the metal most attacked *to* that least attacked through the liquid, and in the opposite direction through the connecting wire.

As in frictional electricity, the part from which the current is supposed to proceed is termed the *positive pole*, and the part to which it flows is called the *negative pole*. Hence in fig. 2, S is the positive and Z the negative pole, *above* the exciting liquid; but beneath, the case

is reversed. The reason of this reversal is clear. The upper parts of the plate S Z, as well as the wires B C, are merely the channels, not the exciters, of the electric current; therefore, whatever may be the electrical disturbance imparted to them, they simply carry it on as conductors, and do not change its nature. To avoid misapprehension, Faraday has given to the terminals of the voltaic couple or battery the name *electrodes*, so that the end of B would be the positive and the end of C the negative electrode. Various substances may be interposed between these electrodes, or they may be plunged into different liquids; and if these are capable of transmitting electricity, the current will still pass, and the phenomena exhibited under a variety of circumstances may be studied. The current, however, was very feeble, and its observed effects very slight, until Volta succeeded in exalting the power of the current by the construction of what is now known as the *voltaic pile*, and still further by his *couronne des tasses*. [VOLTAIC BATTERY.]

Two hypotheses have been propounded to account for the origin of voltaic electricity. According to the so-called *contact theory*, ennunciated by Volta, whenever two dissimilar metals were placed in contact, they always assumed opposite electrical states. This unsatisfactory explanation has now been replaced by what is termed the *chemical theory*. According to this explanation, which has been established by the researches of Faraday, the generation of the voltaic current is referred to the *chemical action* going on in the cell between the zinc and the liquid, which we will assume to be water. It is supposed that the atoms of hydrogen and oxygen, of which water is composed, have inherently opposite electrical states, and are held together by their mutual attraction. It is further supposed that the metal zinc, for example, is electrically different from the state of the oxygen, whilst the electrical condition of the other metal (copper, for instance) is similar to the oxygen, but opposed to the hydrogen. Hence, when these metals are plunged in water and kept separate, their action upon the liquid excites a state of electrical tension between themselves and the particles of the water; a fact which can be ascertained by experiment. The tension is, however, far too feeble for anything like a discharge to take place between their terminals until the ends of the plates are joined, as in figs. 1 or 2. As soon as this is done, the tension is relieved, but is again aroused immediately, so long as the metals and liquid remain the same, only to be as instantaneously discharged; it is these successive discharges, which are linked into and are practically one, that give rise to the voltaic current. The current is, therefore, not created, nor evolved by contact. It is produced by the disappearance of an equivalent of another force; for it has been conclusively shown that the amount of electricity thus developed, or what is termed the *electro-motive force* of the current, is strictly proportioned to the quantity of the positive or oxidisable metal dissolved in a given time; and, further, if the compound which has been formed is or can be rendered liquid by being exposed to another current, precisely that amount of electricity which was generated in its formation will be needed to decompose the substance and restore it to its original condition.

If the wires from a small voltaic battery are terminated with platinum, or some other unoxidisable metal, and these electrodes dipped in acidulated water, bubbles of gas will be seen rising through the water as the electrodes are brought near to each other. These bubbles consist of oxygen and hydrogen gases, and result from the decomposition of the water by the force of the electric current. This fact was first noticed by Nicholson and Carlisle in 1800. The oxygen of the water invariably appears at the positive electrode, i. e. the electrode proceeding from the copper or other inactive plate: the hydrogen always rises from the negative electrode, i. e. the one in connection with the zinc plate. Two test tubes filled with water, and one inverted over each of these electrodes, will collect the rising gas, and show that the volume of the hydrogen liberated is twice that of the oxygen; these are exactly the proportions in which the two gases unite to form water.

A simple nomenclature has been adopted to avoid ambiguity, and to express briefly the facts of electro-chemical decomposition, of which the foregoing is an example. The word *electrode* has already been explained: it here expresses the surfaces where the current enters the liquid and round which the decomposed bodies collect. To the positive electrode, or that connected with the copper or inactive metal, Faraday gave the name of *anode*, and to the negative electrode the name *cathode*: the terms *zincode* and *platinode* have also been used to express the same things, but these words are not in very general use. The decomposition of a body by means of the electric current is termed *electrolysis*, and a substance capable of being *electrolysed*, or electro-chemically decomposed, is called an *electrolyte*. The bodies into which the electrolyte is split by electrolysis Faraday names *ions*; these are divided into two classes, those passing to the positive electrode called *anions* or electro-negative bodies, and those proceeding to the negative electrode called *cathions* or electro-positive bodies.

Besides water many other compounds have, in like manner, been decomposed by the electric current, and substances long regarded as elements were thus discovered to be compounds. By using a very powerful battery, Davy separated potash into the metal potassium and oxygen, soda into sodium and oxygen, and thus revealed these two remarkable metals the existence of which previously was not even conjectured.

It was not long before many other bodies were also found capable of electrolysis, and chemistry as well as physics received a

new impulse by the interesting and startling results thus obtained. Although at first much confusion prevailed from the multitude of new facts, yet it was soon observed that all the effects noticed were subject to regular laws, which in time were investigated and established. The following statements, abridged from Dr. Miller's *Chemical Physics*, comprehend the whole of these laws.

Laws of Electrolysis.—1. *No elementary substance can be an electrolyte.*

2. *Electrolysis occurs only whilst the body is in the liquid state.* This is necessary, in order that the transfer of the particles of the electrolyte which attends the decomposition may take place. Many saline bodies are good conductors and electrolytes when fused, though the thinnest solid film of the substance will arrest the passage of the current.

3. *During electrolysis, the components of the electrolyte are resolved into two groups: one group takes a definite direction towards one of the electrodes; the other group takes a course towards the other electrode.* Oxygen, chlorine, and the acids generally, make their appearance at the anode or positive electrode; whilst hydrogen, alkalies, and the metals are evolved upon the cathode or negative electrode. In the following table some of the elementary bodies have been classified in their electrochemical order; the list must not be taken as absolutely correct, as various experimenters have obtained a slightly different order, according to the purity of the metals used.

Electro-negative

Oxygen	Silver
Sulphur	Copper
Nitrogen	Bismuth
Chlorine	Tin
Iodine	Lead
Phosphorus	Aluminum
Carbon	Iron
Antimony	Zinc
Hydrogen	Magnesium
Gold	Barium
Platinum	Sodium
Mercury	Potassium

Electro-positive

Each substance in this table is electro-negative to the one below it; the greatest differences between any two bodies being found in those which are most widely separated. This table also exhibits what is called an electro-motive series, i.e. if any of the solid bodies in the list are immersed in dilute acid, and one of the bodies below it in the series be immersed likewise, a current will flow through the connecting wire from the one above to the one below in the list. And the greater the distance of the two bodies from each other in the series, the greater will be the electro-motive force of the current generated by their combination. The next law of electrolysis is one of great interest, and of theoretical as well as practical importance. It is as follows:—

4. *The amount as well as the direction of electrolysis is definite, and it is dependent upon the degree of action in the battery, being directly proportional to the quantity of electricity in circulation.* For example, it has been proved that for every 32·7 grains of zinc which are dissolved in any one cell of the battery if local action be prevented, 9 grains of water will be decomposed; or if fused iodide of lead be taken instead of water, 127 grains of iodine and 103·5 grains of lead will be separated for every 32·7 grains of zinc dissolved in the battery. These numbers correspond with the chemical equivalents of the foregoing substances. The discovery of this strict quantitative law led Mr. Faraday to construct an instrument for measuring the strength of the electric current. This instrument, called a *voltameter*, simply denotes the quantity of water, or other electrolyte, which the current has decomposed during a given time.

5. Finally, *those bodies only are electrolytes which are composed of a conductor and a non-conductor*. The conductors accumulate on the cathode or negative pole, and the non-conductors on the anode. A compound substance, consisting of two non-conductors, as bisulphide of carbon, or an alloy formed of two conductors, cannot be electrolysed.

The chemical action of the voltaic battery is not only a valuable agent in research, but is now practically employed on a large scale in some manufactures. It is used chiefly for the purpose of depositing a metal by electrolysis on the conducting surface to be coated. When a solution of sulphate is submitted to electrolysis, metallic copper is precipitated on the negative electrode, sulphuric acid appearing at the positive, where it is again converted into an equivalent of the sulphate if that electrode be of copper. Impressions of coins can thus be taken, and the metallic imprint produced is termed an *electrotype* or Voltatype.

Passing from the chemical action of the voltaic battery, we must notice briefly the phenomena exhibited by the electric current. When the poles of a powerful battery are grasped by the moistened hands, a continuous shock is felt, and the muscles of the body are violently convulsed. The physiological application of the battery, though at first frequently employed, has now been superseded by the use of the induction coil. [Volta-electric Induction.] When a few cells are connected by a wire, a spark is seen at the moment of making and breaking contact; if the number of these cells be increased, the spark becomes more brilliant, and at last glows with steady light, when a sufficient number of cells are employed. With electrodes of coke and a battery of thirty or forty of Grove's cells, a dazzling luminous arc is produced when the poles, having been brought in contact, are separated for a short distance. This is the electric light, and its intense brilliancy and enormous temperature have caused it to be largely employed for lecture illustrations: it has also of late been used for lighthouse illumination with much promise of success.

Not only does the electric current manifest itself when passing between the terminals of the battery, but in a closed circuit, as in fig. 2, the wire which conveys the current possesses extraordinary properties. In the year 1819 a Danish physicist, Oersted, was led to conclude, by the pure effect of reasoning, that the connecting wire of a battery had a magnetic condition. Experiments were made with this end in view; and from these, the same year, Oersted was able to announce, that when the voltaic current flowed through a wire it had the power of deflecting from the meridian a magnetic needle suspended in the neighbourhood of the wire. The direction in which the needle is deflected depends upon its position in relation to the wire, and upon the direction in which the current moves through the wire. If the wire is stretched in the magnetic meridian *above* the needle, and the current flows from *south to north*, the north end of the needle will be deflected towards the west. If one of these two conditions be altered, the effect is reversed; but if both the direction of the current and the position of the needle be inverted, the effect remains the same. By coiling the wire which conveys the current round and round the needle, the feeble action exerted by the single wire is multiplied by the simultaneous and similar action of every coil; hence by this means the effect of a weak current on the needle can be greatly exalted. This is the principle of the GALVANOMETER, which gave rise to the electric telegraph, and is an almost indispensable apparatus in many branches of physical research. Of whatever metal the wire may happen to be which transmits the electric current, it has, during the passage of the current, all the properties which belong to a magnet. Dipped in iron filings, a layer immediately gathers round the wire, and is held there till the circuit is broken. Coiled into a closed helix and suspended, copper wire is made to behave like a compass, turning one end to the north, and having its extremities attracted and repelled by the poles of an ordinary magnet. Steel placed within such a coil becomes a powerful and permanent magnet; and, by winding the wire from a battery round soft iron instead of steel, magnets of enormous power are produced so long as the current flows. These temporary magnets, formed by sending a current of electricity round soft iron, are called *electro-magnets*, and are further described under the word ELECTRO-MAGNETISM.

The *intensity* of the voltaic current at any point in a circuit is found by dividing the electro-motive force of the battery by the resistance—which the current encounters as it traverses the liquid in the cells of the battery and in the wire which joins its poles. The resistance arises from the fact, that electricity passes with greater ease through some bodies than through others. Those substances which transmit the current freely are termed *conductors*, and those which resist its passage *non-conductors*. The metals are of the former class (as also, more or less, are liquids), and gases are of the latter. The metals also differ in conductivity among themselves. This will be seen from the following table, which gives some of the results obtained by Matthiessen on the electric conductivity of commercially pure bodies, the best conductors being represented by 100.

Silver	100	Potassium	20·8
Copper	77·4	Iron	14·4
Gold	55·2	Platinum	10·5
Sodium	37·4	Lead	7·7
Aluminium	33·8	Mercury	1·6
Zinc	27·4	Graphite	0·07

The temperatures of these substances were not all the same; when silver and copper are compared at the same temperature, the difference between them is less than that given. An increase of temperature diminishes the conductivity of solids, but increases that of liquids; these bodies are, however, at all temperatures far inferior to solids as conductors of electricity. If the conductivity of silver be taken as 100,000,000, that of dilute sulphuric acid (1 of acid to 11 of water) would be only 89; and that of a saturated solution of common salt only 31·5, whilst distilled water is represented by the number 0·013, practically a non-conductor. Gases are almost absolute non-conductors of voltaic electricity.

When the electric current traverses bad conductors, the resistance which it experiences causes a part of the current to disappear, but at the same time the resisting medium becomes hot. It has been proved by Joule, that, for currents of equal strength, the heat developed in a wire is directly proportional to the resistance of the wire, i.e. inversely as its conducting power; and, for the same wire, the rise in temperature is proportional to the strength of the current. By using an imperfect conductor, as platinum, many feet of a wire of such a metal may be raised to incandescence, and even fused, merely by the passage of a powerful electric current.

A very copious source of voltaic electricity has recently been obtained from a new application, by Mr. Wilde, of Faraday's discovery of magneto-electricity. In the course of some experiments Mr. Wilde noticed that a small amount of dynamic electricity, when sent round an electro-magnet, produces an indefinitely large amount of magnetism, and by the rotation of a suitable armature in front of such a magnet an indefinitely large amount of electricity is capable of being evolved. No battery at all is necessary; for the current, in the first instance, can be derived by rotating an armature covered with a bobbin of wire in front of a permanent magnet. Starting, then, with a small magneto-electric machine, Mr. Wilde sends the feeble current obtained from it through the coils of an electro-magnet of large dimensions. In front of this magnet another armature revolves, generating a second

and more powerful current. This stronger current is then sent round a second electro-magnet of enormous size. The weight of this magnet is nearly three tons, and its strength, when excited as just described, is enormous. By the revolution of an armature between the poles of this magnet, so great a current of electricity is generated that it can melt pieces of iron rod 15 inches long and ¼ of an inch in diameter, or can heat to redness 21 feet of No. 16 iron wire. The light given between two coke points by this current is so intense, that it is said to cast shadows of the flames of street lamps a quarter of a mile off, and at that distance the rays from the reflector appeared like sunlight. Sensitive paper, when exposed for 20 seconds, at 2 feet from this light, was darkened as much as by one minute's exposure to the direct rays of the midday sun. These brilliant effects are not, however, obtained without the expenditure of force; for it has been found that very considerable steam power is required to revolve the armatures in front of the electro-magnets. Mr. Wilde has thus converted the mechanical motion generated by the expansion of steam by heat into the most powerful source of voltaic electricity with which we are yet acquainted.

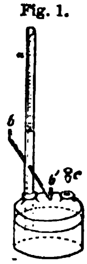
Still more recently (February 1867), Dr. Wheatstone and Mr. Siemens have simultaneously announced their independent discovery of another means of obtaining powerful currents of magneto-electricity by somewhat similar means.

Voltaite. A species of iron-alum, which occurs in dull oil-green to brown or black cubical crystals, and their modifications, at the Solfatara near Naples, and at the Rammelsberg mine, near Goslar in Hanover. Named in honour of the Italian physician, A. Volta.

Voltameter (Ital. volta, and Gr. *μέτρον, a measure*). An instrument contrived by Mr. Faraday for measuring the electro-motive force or strength of a current of voltaic electricity.

The indicating body used in this instrument is generally water acidulated by sulphuric acid. The electrodes are plates of platinum; and the quantity of electricity which has passed is indicated by the quantity of oxygen and hydrogen, resulting from the decomposition of the water, which is evolved, or, in other words, by the weight of water decomposed.

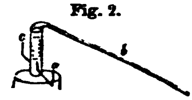
Fig. 1.



When the strength of the current is small, the voltameter represented in the margin is a good form: *a* is a graduated straight tube closed at the upper end, and including two platinum electrodes, connected with the external wires *b b*; through these is sent the current the strength of which is to be determined. The tube is fitted by grinding it into one mouth of the double-necked bottle containing the acidulated water, and is filled by inclining the bottle. When an electric current is passed through the instrument, the gases evolved collect in the upper part of the tube and displace the dilute acid, the stopper *c* being left open. The amount of the gases liberated is read off on the graduated tube, which can be at once refilled by replacing the stopper *c*, and inclining the whole instrument. For every 32·7 grains of zinc dissolved in any one cell of the battery, 9 grains of water are decomposed in the voltameter, and 46·6 cubic inches of hydrogen, or 1 grain, and 23·3 cubic inches of oxygen, or 8 grains, at 60 Fahr. and 30 inches Bar., are evolved upon its plates; at the same time, 46·6 cubic inches of hydrogen are evolved from every platinum plate in the cells of the battery (Miller).

When large quantities of the mixed gases are to be measured, as in cases where the current is left continuous for several hours or days, a voltameter of the accompanying form may be used.

Fig. 2.



The evolved gases pass by the tube *b* into a pneumatic trough, where they are received in a graduated jar and measured: *c c* are the projecting wires by which communication is made with the platinum electrodes, seen as a dotted line inside the glass cylinder, which is nearly filled with acidulated water.

Voltatype or **Electrotype.** The cast of an object obtained by the gradual deposition of a metal from a metallic solution through the agency of a current of electricity. The process can be illustrated as follows: If two pieces of clean platinum are plunged into a solution of sulphate of copper, no change takes place. But if an electric current be now transmitted through the solution, by means of these platinum plates, copper is immediately precipitated upon the platinum, which forms the negative electrode, or cathode, the positive electrode, or anode, remaining clean. If the current be now reversed, the copper will be removed from the platinum plate upon which it had just been deposited, and will be transmitted to the clean plate; and thus, by reversing the direction of the electric current, the copper may be sent backwards and forwards, being always deposited upon the negative pole, or, in popular phraseology, upon that surface by which the electric current leaves the electrolyte, or solution that is undergoing decomposition. By a continuance of the electric current, and keeping up the strength of the solution by the occasional addition of fresh portions of the salt of copper, the metallic film upon the cathode may be obtained of any required thickness, and may afterwards be peeled off the platinum surface. The texture of the deposited copper varies with the battery power employed, and with the temperature and strength of the solution: so that it may be obtained hard, brittle, and crystalline, or malleable and tough, or even pulverulent, according to the management of the operator. A current of low intensity, a moderately strong solution of sulphate of copper acidulated with sulphuric acid, and a temperature not below 60° or 70°, are the cir-

cumstances under which the best deposit of copper is usually obtained for the purposes to which this process is commonly applied.

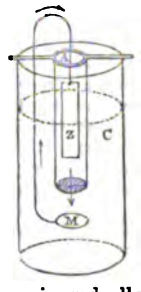
When the negative pole or cathode, instead of being, as above represented, a plane surface of platinum, is irregular (like a medal or coin), an exact impression of the device may be taken off on the precipitated copper. Copies or plates of this kind are known by the name of *voltatypes*, or more frequently are now called *electrotypes*. Gold, silver, and other metals may, by proper management, be substituted for copper; or, if the precipitated metal be left upon the surface on which it is thrown down, gilding, silvering, and coppering may be extensively and beautifully effected. Thus it is that the art of *electro-plating* has also arisen out of these electro-chemical actions.

The merit of first introducing this now well-known and valuable art has been ascribed to several persons. It appears that, in working with his battery, Daniell was the first to notice the deposition of metallic copper by electricity; that, in 1839, Jacobi of St. Petersburg was the first to publish a practical application of this fact, the publication of which evoked announcements from two Englishmen, Spencer and Jordan, each of whom was independently working at the same object, and had attained the same end as Jacobi. Messrs. Elkington almost immediately applied the process to the plating and gilding of goods on a large scale, and their manufactory still holds the first place in this country.

To become an expert at electrotyping, or the *galvano-plastic* art, as it used to be called, requires but little apparatus, and involves but a trifling expense; intelligent care and patience here, as elsewhere, are sure to bring success. Supposing it were wished to take a copy of a medal—it may either be copied directly, and an inverted impression obtained from which a second electrotype can be taken; or a cast of the medal may first be made in wax or plaster. If the latter and most general plan be adopted, the mould, if of plaster, must be first soaked in oil, or immersed in melted spermaceti or tallow so as to render it impermeable to water. The wax or plaster mould must then be made a conductor of the current, and this can be done by thoroughly brushing black-lead over the surface which it is intended to reproduce. When the medal itself is used, in order to prevent the deposition of copper, which would take place upon the edges, and upon the reverse of the medal, those parts should be covered with shell-lac or sealing-wax varnish.

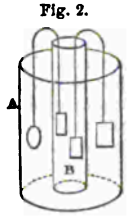
The medal or mould, after being hung in a loop of copper wire, is now ready for the following simple voltaic arrangement: A is a glass cylinder (a common lamp-glass answers the purpose), closed at bottom with a piece of bladder, or with a plug of plaster of Paris, and filled with dilute sulphuric acid (1 of acid to 8 of water by measure); Z is a piece of amalgamated zinc immersed in the acid, and connected by a copper wire with the medal M; C is a jar, or glass tumbler, nearly filled with a strong solution of sulphate of copper, acidulated by the addition of about a tenth part of sulphuric acid. In this arrangement, the acid in the generating cell is prevented from mixing with the solution in the jar by the diaphragm of bladder or plaster; which, however, when thoroughly wetted, suffers the electric current to pass from the zinc to the medal (or negative pole), and so through the wire, in the direction of the darts, back to the zinc. In this way a film of metallic copper is gradually thrown down upon M, which goes on increasing, and when sufficiently thick (perhaps in 24 or 30 hours), the wire with Z and M at its ends is lifted out. By inserting the point of a knife the deposited copper is released, and when pulled off of M presents a faithful and minute impression of the object.

Fig. 1.



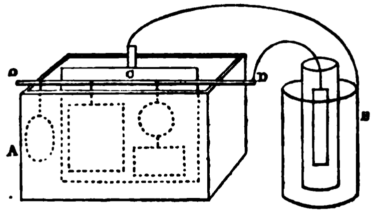
In the case of seals, coins, and other small articles, a number of them may be put in process at once by the following modification of the above described apparatus. A is a jar filled with a saturated and slightly acid solution of sulphate of copper; B is a porous earthenware cylinder, similar to those used in Daniell's constant battery, filled with dilute sulphuric acid. The articles to be coated with copper are prepared as above described, and attached to copper wires having a small piece of zinc at their other end; several of these may then be suspended round the porous tube; and thus the zinc being in the acid, and the coin or seal in the cupreous solution, the process goes on until the electrotype is perfect.

Fig. 2.



When a number of articles of different sizes are to be electrotyped, the following arrangement is generally adopted where the process is employed upon a large scale; as in preparing electro-types from wood-cuts, copper-plates, plaster casts, &c. A is a trough of any required dimensions, made of slate or wood, generally lined with marine glue, and filled with a proper solution of sulphate of copper; C is a copper plate immersed in the trough, and

Fig. 3.



forming the positive electrode of a Daniell's battery B (of which one cell only is here represented, but of which two or more may be employed as required); D D is a copper rod forming the negative electrode, to which the articles to be coated with copper are suspended by copper wires. These several articles, previously prepared as described, are retained in the circuit till adequately coated by copper. In this form of apparatus the sulphate of copper solution is maintained at its original strength; for, as the copper is deposited upon the mould, the sulphuric acid liberated at the positive pole converts an equivalent of the copper of the plate C into the sulphate. Numerous applications have been made of the process of electrotyping; engravings are copied, music is printed, busts and other figures are cast, ferns, seaweed, and flowers moulded in metal, and above all daguerreotypes reproduced, with wonderful faithfulness and detail.

The other application of electro-metallurgy is the covering one metal with a thin crust of another; a process even more generally useful than the reproduction of objects. For coating articles with silver, a bath is made containing 1 part of cyanide of silver to 2 or 3 parts of cyanide of potassium, dissolved in about 150 parts of water. The article to be plated is made the negative pole, and a piece of silver hung in the bath forms the positive electrode. The silver will be deposited with a dead appearance; if lustre is required, a few drops of bisulphide of carbon added to the bath will effect this object. Articles may also be gilded by employing a solution of the double cyanide of gold and potassium. In all cases where silver or gold is to be deposited, so as to give a durable adhesive coating, the articles must be perfectly clean. For this purpose they must be boiled in a weak alkaline solution, then dipped in dilute nitric acid, and afterwards well washed immediately before putting them in the bath. Other metals, besides copper, silver, and gold, can be electrically deposited from their solutions; of these the most successful and useful as yet employed is the coating of iron with zinc, a solution of sulphate of zinc being here employed. Alloys of the metals have also been deposited, but the processes are attended with practical difficulties. [VOLTAIC BATTERY.]

Volti (Ital. *turn*). In Music, a term directing that the leaf is to be turned over.

Voltzine or **Voltzite.** A native oxysulphide of zinc, composed (when pure) of 82·7 per cent. of sulphide of zinc, and 17·3 oxide. It occurs in small hemispherical incrustations of a dirty rose-red colour, which are opaque or only slightly translucent, and have a vitreo-resinous lustre, at Rozières, near Port Gibaud in Auvergne; and at the Elias Mine, near Joachimsthal, Bohemia. Named after Voltz, French engineer of mines.

Volubilis (Lat. *rolling*). In Botany, a term applied to stems or leaf-stalks, and similar bodies which have the property of twisting round some other body.

Volume (Lat. volumen, from volvo, *I roll*). A book. Thus a library is said to consist of so many thousand volumes, and a long work is divided for convenience into several volumes. Every single roll of paper or parchment, in an ancient library, was of course equivalent to a single book in one of our own. The French word *tome* (signifying, properly, a single volume of a work containing more than one) is the Greek *τόμος*, from *τέμνειν*, *to cut* or *divide*.

VOLUME. In Geometry, this term denotes the quantity of space, of three dimensions, enclosed by a surface or surfaces. The volume of a body, or its *solid content*, is the quantity of space which it occupies. For methods of estimating volumes, see CUBATURE.

Volumetric Analysis. A method of quantitative chemical analysis in which the balance and other elaborate apparatus are more or less dispensed with; a few glass vessels, some graduated, being alone necessary. It consists in ascertaining how much of a solution of definite strength and properties must be added to a solution of unknown strength before a given effect, indicative of the termination of a chemical reaction, can be produced. Many solutions of unknown strength can thus have quantitative values rapidly given to them. For illustrations of the process, see ALKALIMETRY.

Volunteers. The most ancient volunteer force in Great Britain is the Honourable Artillery Company of the city of London, which is perhaps the oldest military body in Europe, and received a charter of incorporation from Henry VIII. When Napoleon's design to invade England in 1803 became known, a large force of volunteers was enrolled, the returns for that year showing 463,134 effectives. The numbers soon declined, and shortly after 1815 they ceased almost entirely to exist.

The volunteer organisation as now established arose in 1858, though the Victoria Rifles, and one or two other corps, had been formed previously. In 1859 a large force was formed, and an inspecting staff established. The Act 26 & 27 Vict. c. 65 (1863) now regulates the formation and system of volunteer corps. They are also subject to the provisions of the Order in Council, July 27, 1863, and to all regulations made regarding them by the Secretary of State for War.

In time of peace the adjutants and serjeant instructors are subject to the provisions of the Mutiny Act and Articles of War. The other officers are not subject to military law, but can be deprived of their commissions by authority of her majesty; and the non-commissioned officers and privates are liable to fine and dismissal under certain rules. In case of invasion, actual or apprehended, her majesty may direct the lords-lieutenant of counties to call out any volunteers, who are bound to march anywhere within Great Britain. All officers and men thus called out become subject to the Mutiny Act and Articles of War, and receive pay and allowances corresponding to

those of the similar branches of the regular army.

The volunteer force, including yeomanry, takes precedence immediately after the militia; and the various corps rank as under: light horse artillery; engineers; engineer and railway transport; mounted rifles; rifles. On the formation of a corps, it receives an establishment and a number.

The members of a corps are either *honorary* or *enrolled*. Enrolled members are classed as *efficient* and *non-efficient*. The qualifications for efficient members are defined by an Order in Council of July 27, 1863.

The staff of the volunteer force consists of 1 inspector-general, 1 deputy inspector, 10 assistant inspectors, and 3 honorary inspectors of musketry. The pay and allowances for the volunteer force are as follows: Adjutants and serjeant instructors receive permanent pay and allowances. An annual capitation grant of 30*s*. for each effective volunteer is given to each artillery corps: 20*s*. for other corps, with a special allowance of 10*s*. each for men fulfilling certain conditions. Administrative battalions have, under certain regulations, an extra allowance of 4*s*. for each effective. Arms and ammunition for practice are supplied at the public expense.

The total number of yeomanry and volunteers now (1866–7) borne on the muster rolls is 193,523 of all ranks, which are as follows: Yeomanry cavalry, 14,268. Volunteers—Staff at head quarters, 12; adjutants, 280; Honourable Artillery Company, 901; light horse, 830; artillery, 32,010; engineers, 4,823; mounted rifles, 438; rifles, 139,961. For further information, see *Army of Great Britain*, published annually by authority, at the statistical department of the War Office.

Voluspa Saga. A short saga, in which a theogony is combined with a cosmogony, and in which the fortunes of the world are traced to the twilights of the gods when Odin and the Æsir are all doomed to perish. The age of this saga is doubtful.

The word Voluspa means the *spa* (Scotch *spae*), or prophecy of Vola, the inspired or mad prophetess (whence the English *fool* and *folly*). With the first part of this word may be compared the name of Veleda, the prophetess of the Bructeri, mentioned by Tacitus. (*Hist.* iv. 61.)

Voluta (Lat. *a volute*). A name applied by Linnæus to a genus of the *Vermes Testacea*, including those which have a univalve spiral shell, with an aperture without a beak, and somewhat effuse; and a columella twisted or plaited, generally without lips or perforation. The Mollusca thus characterised form a family in the Buccinoid tribe of the Pectinibranchiate Gastropods of Cuvier's system, and are distributed into the following subgenera: *Oliva*, Brug.; *Volvaria*, Lam.; *Voluta* proper; *Cymbium*, Montf.; *Marginella*, Lam.; *Columbella*, Lam.; *Mitra*, Lam.; *Cancellaria*, Lam.

Volute (Lat. volvo, *I roll*). In Architecture, the spiral scroll appended on each side to the capital of the Ionic order. The Corinthian and Composite capitals are also decorated with volutes; but their character is different, their size smaller, and they are always diagonally placed. In the Corinthian order they are more numerous, and in the Composite they are larger than in the Corinthian.

Volva or **Wrapper.** In Botany, a term used in describing fungi to denote the involucrum-like base of the stipes of *Agaricus*. It was originally the bag enveloping the whole plant, but was left at the foot of the stipes when the plant elongated and burst through it.

Volvulus (Lat. volvere, *to roll up*, because it was supposed to arise from twisting of the intestines). The contractile action of the membranes of the intestines, usually termed *cholic* or *gripes*. [Iliac Passion.]

Vomica (Lat. vomo, *I spit up*). A cavity in the lungs, which is the result of softening of deposited tubercle in phthisical persons. These cavities apparently may also result from degeneration and softening of fibrinous material deposited in the lung.

Vomicina or **Vomicine.** A name given by some pharmaceutical chemists to the alkaloid more usually termed *Brucia*, obtained from the bark and seeds of the *Nux vomica* and from *St. Ignatius' bean*; it is usually associated with *Strychnia*. [Brucia.]

Vomitoria (Lat. vomo). In Architecture, the openings, gates, or doors, in the ancient theatres and amphitheatres, which gave ingress and egress to the public.

Voraulite. A name for the ferro-magnesian phosphate of alumina, met with in a gangue of quartz, at Waldbach, near Vorau, in Styria. It appears to be a species of *Blue Spar* or *Lazulite*.

Vorhauserite. A mineral from the Fleims Valley in the Tyrol, with the same composition as Retinalite, but rendered impure by an admixture of small quantities of theoxides of manganese and iron. Named in honour of Vorhauser, a Tyrolese minister.

Vortex (Lat. another form of vertex). An eddy or whirlpool; a body of water running rapidly round and forming a cavity in the middle, into which floating bodies are drawn. The term is also applied to whirlwind.

In the Cartesian philosophy, vortex signifies a collection of material particles, forming a fluid or ether, endowed with a rapid rotatory motion about an axis. By means of this hypothesis and the received doctrine of centrifugal forces, a plausible explanation may be given of the motion of the planets, which move nearly in the same plane; but the motions of the comets which traverse the heavens in all directions are inexplicable, and in fact are inconsistent with the hypothesis. Descartes, nevertheless, had the merit of attempting to show how the universe might have assumed its present form and be preserved on mechanical principles. For an explanation of the system of vortices, see Maclaurin's *Account of Newton's Philosophical Discoveries*.

Electric and magnetic phenomena have also been explained by the *Theory of Molecular Vortices*. (*Phil. Mag.* 1861.)

Vorticel (Lat. vortex). The generic name of certain pedicellate Wheel Animalcules, provided with vibratile organs at their anterior extremity, whose apparently rotatory actions produce little whirlpools in their vicinity, and thus attract the particles of food.

Vosgite. A kind of Labradorite which has become hydrous through undergoing a partial alteration, and which constitutes the porphyry of Ternuay in the Vosges.

Voussoir. One of the wedge-shaped stones of an arch, by the proper disposition of which, in a semicircle or other curve, the arch is formed. The centre stone of the arch is called the *key stone*. The inferior surface of the arch is called the *intrados* or *soffit*, and the exterior the *extrados* or *back*.

Vow (Lat. votum). Solemn promises to God, and under religious sanction, are spoken of in the Old and New Testaments under this name. The Jews recognised three sorts of vows: of devotion, of abstinence, of destruction or extermination (anathema). In the Church of Rome, vows are divided into *solemn* (taken in the face of the church) and *simple* (or private). Release from a vow must be obtained from a spiritual superior, who has power to grant it. Five vows were said to be reserved for papal dispensation only: that of chastity; the vow to enter into a religious order; vows of pilgrimages to Rome and to Compostella; and the vow of a crusade. Monastic vows are now most commonly understood when vows are spoken of. [Monachism; Orders, Religious.]

Vowel (Fr. voyelle; Lat. vocalis, from vox; Gr. ἔπος). In Grammar, a letter which can be pronounced alone, thus distinguished from consonants, which require to be sounded with the aid of a vowel. They are divided in ancient prosody into *long*, *short*, and *common* (ancipites, i.e. either long or short at pleasure). A diphthong consists of two vowels, of which the sounds run (or are supposed to run) into one another.

Voyol. A rope used on Shipboard to bring the pressure of the capstan to bear on the cable without the necessity of winding the latter round the barrel.

Vritra. In the Vedic Mythology, the cloud-enemy of Indra, who lets loose the imprisoned waters by putting him to death. The idea expressed in the myth is precisely that which is embodied in the legend of the Theban Sphinx. The name Vritra denotes a being who hides or veils, and belongs to the same root with Varuna [Uranus], and reappears in that of the Greek Orthros [Cerberus]. This monster is identical with Ahi, the great serpent or throttler, who reappears in the Greek Echidna, the Latin anguis, from the root *ah*, or anh (as in ango, angina), *to throttle*. Thus in the Vedic hymns Indra is especially known as Vritrahan, or the slayer of Vritra, and thus also Vritra became, in course of time, a mere generic name for an enemy. In the conflict he stands to Indra in precisely the same relation as Geryon or Cacus to Heracles. But, as with other early Vedic beings, the names are not finally fixed, and the attributes are to a certain extent interchangeable. Vritra is called sometimes Ahi, sometimes Vala, Pani [Paris], &c. and he is opposed sometimes by Indra and at other times by Agni, Trita [Tritogeneia], and other gods. Like Cerberus, Vritra has three heads, and he swallows the cows, which Indra rescues from his jaws, as Hercules delivers them from the cave of Cacus. These cows are the clouds which water the earth, and are prevented by malevolent powers from bestowing their gifts on the sons of men. Thus, in Greek myths, dragons are commonly represented as guarding fountains. Cadmus kills the monster who kept the fountain of Ares, near Thebes; a stream of water leaped up from the earth when Apollo slew the Python; and the apples guarded by the dragon in the land of the Hesperides are only the cattle (μῆλα, the same word having both meanings) which in the *Odyssey* are fed by Phaethusa and Lampetie in the pastures of the sun.

In India, this myth retained to the last, in great measure, a merely physical signification. The battle between Indra and Vritra was the battle of the sun-god with the dark thunder-clouds which keep the rain from falling on the earth; the struggle of Œdipus with the Sphinx, of Achilleus with Hector, of Odysseus with Melanthius and his accomplices. But the tendency to invest the myth with a moral or spiritual meaning is manifest in some Vedic passages which contain a prayer beseeching Indra with the Maruts [Thor] to smite Vritra, 'that the wicked one reign not over us;' but the change was not fully accomplished till the myth was transplanted to Iranian soil; and there from it sprang the Zoroastrian Dualism which divided the empire of the Cosmos between the beneficent Ormuzd and the malignant Ahriman. But although the myth, thus spiritualised, assumed a form which has exercised a momentous influence on religious belief down to the present day, the names remained for the most part the same. The Vedic Vritra reappears in the Zend Verethra, and Vritrahan is seen in Verethragna (the modern Behram). Nor is the name Ahi wanting. The throttling serpent is found in Azi or Aji, who received the epithet dahâka, or enemy, and from the union of the two words is formed the modern Zohak, who is slain by Feridoun. [Thraêtana.] It cannot be denied, however, that the Iranian Ahriman is a far more important being than the Brahmanic Vritra. The former has been exalted in a measure corresponding to the dignity of Ormuzd as compared with the Vedic Indra, until from the cloud enemy of the gods (adeva, Gr. ἄθεος) he has become the creator of an evil world peopled by hosts of malignant demons. Thus the myth, as professing to account for the phenomena of the moral world, becomes metaphysical, and is lost in the de-

velopement of Parseeism. This Iranian demonology is seen in the ASMODEUS of the Book of Tobit, and in the dragon whom Christian art represents as crushed beneath the feet, and pierced by the lance of St. George. (Bréal, *Hercule et Cacus*; Muir, *Sanskrit Texts*; Max Müller, *Lectures on Language*, second series.)

Vritrahan. [VRITRA.]

Vulcan. In Latin Mythology, the god of fire. The name is connected by some with the words *fulgere*, to glisten, and *fulgur* and *fulmen*, lightning; by others, with the Sanscrit ulkâ, *a firebrand* or *meteor*. The legends about Vulcan are mere reproductions of the myths which grew up round the name of the Greek god HEPHÆSTUS, with whom the Latin deity was in course of time completely identified.

Vulcanite. Synonymous with EBONITE. A good vulcanite is made by heating to 300° Fahr. for six hours a mixture of two parts of caoutchouc and one part of sulphur. Vulcanite resembles horn in appearance; it is much used for making combs, and being an excellent insulator has been recently proposed as the best material for the covering of telegraph wires.

VULCANITE. A Mineralogical synonym of Pyroxene (Augite) or Volcanic Garnet.

Vulgar Fractions. In Arithmetic, any fraction whose denominator is a power of 10 is termed a *decimal fraction*. [FRACTION.] All others are called *vulgar*.

Vulgate (Lat. vulgata, *for public use*). The name given to the Latin version of the Scriptures in use in the church of Rome; the greater part of which is the composition of St. Jerome. It is decreed by the council of Trent that the Vulgate is to be 'held as authentic,' which, according to the interpretation usually put on the decree by theologians, means not that it is in any way substituted for the originals, but that it contains nothing contrary to true faith and morals. (Milman, *History of Latin Christianity*, book iii. ch. xi.; Hallam, *Literary History*, part i. ch. vi. p. 39.)

Vulpes (Lat.; Ital. volpe, *a fox*, akin to Gr. ἀλώπηξ, Sansc. lôpâça, Eng. *wolf*). This has been made a subgeneric term by those naturalists who so distinguish the foxes from the dogs, jackals, and wolves, to which they consequently restrict the term *Canis*. The grounds for the proposed distinction are chiefly that the form of the pupil of the eye is vertical in the foxes, and circular in the dogs; the lobes of the upper incisor teeth are less distinctly marked than in the dog; the tail of the fox is longer and more bushy; its head broader, and terminated by a narrower and more pointed muzzle; its gait and attitude crouching.

Vulpinite. So called from Vulpino, near Bergamo in Italy, where it is found. An anhydrous sulphate of lime (Anhydrite), containing about 8 per cent. of silica. It is sometimes employed by Italian artists for small statues and other ornamental work, under the name of *marmo bardiglio di Bergamo*.

Vultur (Lat. *a vulture*). The name of a Linnæan genus of diurnal Accipitrine birds, characterised by an elongated beak, curved only at the extremity, and by having a greater or less proportion of the head, and sometimes of the neck, denuded of feathers. To the brief Linnæan phrase descriptive of this genus it may be added, that the power of the claws does not correspond with the bulk of the body. The wings are so long that they are carried in the half-extended state when the vulture walks on the ground. In general, the birds of this group are of a cowardly nature, living on dead carcases and offal; their gullet dilates into a considerable crop, which, when distended with garbage, projects above the furcular bone. When the vulture is gorged with food, a fœtid humour is discharged from the nostrils, and the bird is reduced to a state of stupidity. The vultures of Linnæus are divided into the subgenera *Vultur*, Cuvier; *Cathartes*, Cuvier; *Sarcoramphus*, Cuvier; *Percnopterus*, Cuvier; *Gypaëtus*, Storr.

W

W. A letter found only in the alphabets of modern languages. In form, it resembles two V's, and its English name is derived from the fact of the letter *v* being identical with *u* in the Latin, and in the more early form of the English language. In German, *w* is pronounced like the English *v*; the latter having the sound of *f*. When *w* commences a syllable, it is a consonant; but in all other positions, a vowel.

Wacke. A German Geological term, now rarely used. It originally meant a soft and earthy variety of basalt. [GREYWACKE.] Other metamorphosed rocks of considerable hardness have received the same name.

Wad. A local name, in Derbyshire and the north of England, for Graphite or Plumbago. In Mineralogy, the term is used to denote various mixtures of different oxides of manganese, which cannot be always considered as distinct species or as having a very definite chemical composition. The name has reference to the light forms, resembling *wadding*, assumed by the mineral.

Waders (Ger. waten, Dutch waaden, *to wade*, akin to Lat. vado, and Gr. βαδίζω, *to go*). An order of birds, including those which have long legs naked from above the distal or lower extremity of the tibia downwards. [GRALLATORES.]

Wads (Ger. watte). In Artillery, wads are of four kinds: *junk* [JUNK WADS]; *grummet* [GRUMMET WAD]; *papier-mâché*, being small discs used for closing the fuze holes of

filled common shells and the loading holes of diaphragm shells; and *coal dust*, being serge bags filled with coal dust, and placed inside the 5-lb. cartridges for 8-inch guns, to fill up the chamber.

Wadset. In Scottish Law, a method of mortgaging landed property. It is now obsolete, having been superseded by the *bond and disposition in security*, consisting of a covenant for payment of the debt and a conveyance of the land by way of security, with a power of sale; the practical effect of the whole being much the same as that of an English MORTGAGE, except that the debt constitutes REAL PROPERTY, and not, as in England, PERSONAL PROPERTY of the creditor.

Wafers. Adhesive discs for securing letters or sticking papers together. Common wafers are punched out of a paste made of very fine flour which is pressed between two heated plates of smooth iron. Transparent wafers are made of films of isinglass or gelatine, dried upon plate glass, and punched out of various forms and sizes. Wafers are coloured with various materials, but care should be taken that these are not, as is often the case, of a poisonous nature. The wafer makers are very unwilling to show the process.

Wager (Ger. wagen, *to venture*). In Law, wagers were formerly valid, and might be made subjects of action, unless they were on illegal matters, but now (by stat. 8 & 9 Vict. 109) all contracts by way of gaming or wagering are null and void, nor can a deposit on a wager be recovered from the stakeholder. But this last provision does not apply to subscriptions for prizes at lawful games or pastimes.

Wager of Battle. The usage of deciding a civil suit by battle was common to the jurisprudence of many of the Teutonic tribes which established themselves in the provinces of the Roman empire. It was especially favoured among the Lombards; and there is a celebrated passage in the laws of their king Luitprand, in which, while he recognises the impiety of the custom, he professes his inability to abolish it in consequence of the prejudices of his subjects. In England, battle trial is not mentioned in any Anglo-Saxon laws now extant; and its introduction is therefore attributed to William the Conqueror, although bearing in his laws the Saxon name of *orneste*, probably *earnest.* Sir F. Palgrave (*On the British Commonwealth*, chap. vii.) believes that the Conqueror did no more than confirm a usage already known to the inhabitants of England. He supposes that battle in civil suits was regularly joined in the Anglo-Saxon county courts. Trial by battle, by the English common law, was used in civil cases only, where issue was joined upon a writ of right, in which the tenant pleaded the general issue, viz. that he had more right to hold than the demandant to recover, which he offered to prove by the body of his champion; for in civil actions the combat was not between the parties themselves. The champions were armed with bâtons and targets, and the combat took place before the judges and serjeants of the Court of Common Pleas. The court ought to sit (says Blackstone) by sunrising, and the combatants were bound to fight until the stars appeared in the evening; and if the champion of the tenant could either hold out so long, or obtain the victory, the tenant prevailed in his cause. Victory was obtained either by the death of the champion, or by his pronouncing the horrible word *craven*, which caused to his principal the loss of his land, and legal infamy to himself. The trial by battle was the only mode of deciding a writ of right, until Henry II. introduced the grand appeal or trial by inquest, and gave the tenant his choice between them. The last trial by battle in the Court of Common Pleas was in the 13th Elizabeth, 1571, on which occasion the lists were set up in Tothill-fields (Dyer 301); but in the Court of the County Palatine of Durham there was one in 1638. Trial by battle in criminal cases is explicitly noticed in the laws of the Conqueror. It took place on an *appeal*, when the appellee of felony pleaded not guilty, and declared that he would defend the plea with his body: as in *approvement*, when a party arraigned of treason or felony became an approver by appealing, or accusing his accomplices, the latter might in the same manner demand trial by battle. In this case the combat was between the parties themselves. The last trial by battle awarded in this country was in the case of Lord Reay and Mr. Ramsay, in the 7th of Charles I.; but the king, after having appointed a constable to preside, revoked the commission. In 1818, William Ashford having brought an appeal against Abraham Thornton for the murder of his sister, the appellee waged his battle. Judgment was stayed in consequence of a legal difficulty which arose in the case; and in the following year an Act was passed, by which appeals of treason, felony, and other offences, and trial by battle on writs of right, were abolished. [RATIONALISM.]

Wager of Law. [COMPURGATION.]

Wages (this word may be traced to the same source with the Latin vas, vadis, *surety*, through the Old High German wette, *a pledge*, Gothic vadi, in mediæval Latin wadium or vadium, Ital. gaggio, and Fr. gage). In Political Economy, the payment made for such muscular or nervous labour as possesses a value in exchange. The popular use of the term is somewhat loose. It generally limits the word to mechanical or muscular labour, and to such private revenues as are derived from advances made by capitalists. Such an interpretation, however, is not only vague and unphilosophical, but tends to great errors, which may in the practice of finance become serious wrongs.

All income is derived from wages, profits, rent. Sometimes, however, these three elements are united in the same person, and are not distinguishable except by analysis. In the articles PROFIT and RENT an attempt has been made to show what is the part assignable to each of these elements. It remains to offer some comments on the position occupied by wages.

The rent of land is derived entirely from the natural powers of the soil, or from capital sunk in improvements. The profits of capital are derived either from permanent investments, or from loans made on security which cannot be impugned. If the investment be liable to depreciation, or the security to discredit, a payment is always expected on the ground of risk or hazard. It is plain, however, that such a payment is no part of profit. Capital may be invested in a variety of ways, as in draining land, in constructing railways, in building houses. But capital is equally invested in the education of artizans and of professional persons—of all persons, in short, who live entirely and exclusively on labour; and in so far as the rate of payment made to them is in consideration of the capital invested in such an education, so far is it profit on capital, and not wages. Again, in so far as the payment (after estimating, in a general way, the cost or outlay of capital incurred in physical, mechanical, and intellectual education) is in excess of the rate of profit procurable, on an average, from such an amount of capital invested in a permanent form, so far does the payment tend to replace the capital invested, and to cover the risks involved in such occupations. And if equal capacity for supplying services in demand is attained under less cost, or superior and exceptional capacity is exhibited, the analogy subsisting between natural abilities, whether mental or bodily, and singular fertility in certain soils, is manifest and clear.

The power of obtaining wages invariably therefore implies the outlay of capital in the maintenance and education of the labourer; and the rate of wages will, some risks being estimated, and some machinery for replacing the waste of capital being implied, be therefore relative to the rate of profit. The maintenance of a child in the cheapest and most economical form—that, for instance, in an industrial workhouse school—will represent at the end of ten years, at 5 per cent. compound interest, little less than 100*l.*; and of course, if the age at which the labourer is able to earn his or her living is more protracted, and the cost of maintenance and education larger, the existence of such a person will represent a still larger sum invested as capital, when interpreted from an economical point of view, and liable, because invested in this form, to certain depreciation and numerous risks. Furthermore, the cost of supplying such labour will include not only the particular depreciation and risk to which such an investment is liable, but all losses which premature death and disease induce upon similar employments of capital, distributed over those who survive as efficient labourers. It is not indeed important, for the purpose of analysing the cause of wages, that the charge should be borne by the parents of the child, or that the risks should be incurred by the labourer himself. They may be incurred by third parties, and under the machinery of a poor law they are largely so incurred in the case of common labour. It is only important to observe, that unless this perpetual investment of capital in the supply of labour goes on, the supply would rapidly diminish, rates of wages would rise from deficiency, and rents would fall. It is only because labour is ordinarily in excess of demand, that the true facts as to the economical investment of capital in the maintenance and education of labour are hidden or escape notice. When, as in newly settled countries which possess large tracts of fertile and unoccupied land, population increases rapidly, but not so rapidly as capital, it is seen that the supply of labour is one of the most important forms in which capital may be employed.

A confusion, then, between the income derived from wages—the word being used in the widest sense, to include all labour however rude or however refined—and the profits derived from stock, or rent derived from land, is unphilosophical, and the subjection of both to equal rates of taxation, whether the tax be levied on the consumption of articles necessary to maintain life or on net income, is unfair, because it takes from the profits of capital in the one case, and from capital itself in the other. In taxes at present levied on consumption, few of an absolutely objectionable character exist, the principal of these being the sugar duties and the existing duty on corn; but the wrongs of the income tax are incontestable.

It has been already remarked that the real origin of wages is obscured by the fact that labour is generally in excess of demand. Hence, it is ordinarily related to supply, instead of being valued, as it ultimately must be, by the amount of labour or capital expended in bringing it into existence; in other words, by the cost of production. To this condition, labour, like every other article of value in exchange, except rent, must conform in the end. It will not on the spot where it is produced be remunerated at a higher rate than the costs at which it is produced; it cannot, to be produced at all, fall much below it.

There are always, however, certain circumstances qualifying the rate of wages within certain limits, which do not affect other utilities in an equal degree. The fact that labour is less easily transferred, as a rule, than other objects, tends to depress the rate. This immobility of labour is due partly to factitious causes, partly to personal motives operating on the mass of mankind. The laws which have for so many ages attempted to compel the residence of labourers to given spots are instances of the first set of causes. In feudal times the intimate relations which were supposed to exist between the various classes of society, interpreted of course with greater stringency in the case of the peasant, put a variety of hindrances in the way of migration from place to place. When the labourer possessed, as he generally did, land as the reason of his dependence on the lord, he could not migrate without forfeiting his tenancy. This condition was extended to the lord's dependants, who could not escape from

a particular locality, except by paying a fine. [VILLEIN.] Another cause of the same character was the police exercised in that time. A landless and lordless man was an outlaw, or vagabond, and was generally treated, and probably with justice, as a thief. Again, when in consequence of the great plague of 1348 the price of labour rose enormously, the law attempted, in the interest of landowners, to check migration. An attempt to fix wages at low rates must, in order to have any operation, attempt also to hinder the departure of labour from its customary field of employment. Finally, when labour became in excess of demand, and the law provided that unemployed labour should be maintained, similar checks were put on the voluntary removal of labourers in order to obviate the risk of maintaining extraneous labour. This was the effect, if not the origin, of the law of settling the poor to particular localities, in pursuance of certain acts which were construed to give a special interest or right in a certain place. [SETTLEMENT.] Such causes, when in existence for a time, will be sure to operate on the mobility of labour, even after they have been formally repealed, or practically abandoned.

On the other hand, there are causes which check the natural power of motion possessed by labour, and which are derived from the sympathies of the labourer himself. The love of home, friends, family, and the feelings generally which are the foundation of the feeling of patriotism, are great hindrances to migratory enterprises. Even when the area of occupation is practically unbounded, as it is in newly settled countries, the part of the community which moves to new fields of enterprise is small, and much more frequently derived from immigrants than from native inhabitants; while in older and more fully settled communities, the disposition to emigrate requires to be fostered, and, except under peculiar circumstances, is very imperfectly developed. Great as has been the emigration from England, it is questionable whether it has ever raised the rate of wages even in an infinitesimal degree. As far as can be gathered from the census of the people in 1861, the home migration, i.e. the transit of population from the agricultural to the manufacturing districts, from the country to the town, has been little more than the absorption of the overplus. In such a migration, it is clear that emigration is a secondary process, and that, if the former is ineffectual to raise the rate by scarcity, the latter is still less likely to do so.

But if ordinary causes, and even the clear knowledge that labour will be largely benefited in seeking distant employment, are only scantily operative to raise the rate owing to the general immobility of labour, other causes tend to prevent its depression. Thus, for instance, custom is, in the absence of any great or organic social change, a bar to the operation of those causes which might reduce wages by their own force. It is upon agricultural wages that custom is most effective. Any considerable lowering of the rate, even conjointly with the poor-law relief, would ultimately raise rents, and be of little benefit to the farmer. The farmer has no great motive to reduce wages. He may entertain a conviction that any cheap labour is ineffective; he is certain that no special economy of his own, induced on the cost of production, will remain long to his benefit. Still more powerful is the customary food of the people, below a fair amount of which, as supplied by the earnings of labour, wages will hardly fall. Money wages, and the purchasing power of these money wages, are always higher where the labourer lives on dear food, as wheat, when compared with wages where he is content with a lower food, as oats, maize, or rye. To say that the 'habit of secondary wants' is a check to population, is only another form of stating the fact that labour will not increase, and ultimately will not be supplied, if the customary wants of the labourer are ill provided for. Again, if under any extraordinary circumstances the supply of labour falls far short of the demand, wages may undergo a considerable rise, and this rise may be permanent; i.e. the mass of the community will not accept lower wages, and will emigrate or abstain from marriage, rather than run the risk of diminished labour payments. Such a great exaltation of the wages of labour took place after the great plague of 1348 [LABOURERS, STATUTE OF], and similarly a great depression of the wages of labour followed on the currency schemes of Henry VIII. in 1543.

But though the rate of wages is permanently affected by the kind of food ordinarily consumed by the labourer, it is not affected by the market price of this food. Wages are not necessarily high when food is dear, low when food is cheap. The cause of cheap food is quite distinct from the cause of low wages, the former depending on the plenty of the seasons and the abundance of fertile land, the latter on the density of population. In countries where food is cheapest, while the countries themselves are rising in opulence, wages are highest. The fact that food and labour prices depend on different causes is a little obscured in this country by the operation of the poor laws, for they who contribute the largest amount to the poor rate find it better to increase the wages of their labourers than to pay the money which they might devote to this end to a common fund from which they could derive no benefit, or only an indirect benefit. [PAUPERISM; POOR LAWS; POPULATION.]

Attempts to raise the rate of wages by a machinery adopted by labourers themselves have been already commented on. [TRADES' UNION.]

For the effect induced upon wages by the great plague of the fourteenth century, see Rogers' *History of Agriculture and Prices*; for information as to the rates of wages in Europe, see La Play, *Les Ouvriers Européens*.

Wagite. A concretionary hydrated silicate of zinc, from Nijni-Jagurt in the Ural, of a colour varying from pale blue to green. Named in honour of Waga, the naturalist, of Warsaw.

Wagnerite. A very rare mineral, named after Von Wagner. It is a phosphate of magnesia associated with fluoride of magnesium, and is found in the valley of Hollengraben, near Salzburg, in Austria.

Wahabees or **Wahabys.** A Mussulman sect, of which the founder was a learned Arabian, named Abd el Wahâb, who became persuaded of the corruption, both of doctrine and practice, prevalent among the professors of Islam, especially the Turks. His daughter married Mohammed Ibn Saoûd, the principal person of the town of Derayeh, who became his first convert and leader of the sect about 1760. Like the original prophet of their faith, Saoûd and his followers propagated their doctrines at once by persuasion and arms. Abd el Aziz and Ibn Saoûd, the son and grandson of the first Saoûd, carried their arms to the utmost extremities of Arabia, and, conformably with the old Mohammedan principle, established a spiritual and temporal leadership united in their persons. The Bedouins, or wandering tribes, formed the bulk of their converts. They acknowledged the Koran and the Sunne, or orthodox tradition, and they professed adherence to the liberal tenets of both; but they accused the other Mohammedans of an idolatrous veneration for the Prophet and other saints, and denied the intercession of saints altogether. Like the early Protestants of Europe, their favourite taste was the destruction of the cupolas and tombs of saints. To this the mob of Wahabees added a strong aversion to the rich dress of the Turks, and to the practice of smoking tobacco, which had been prohibited by Abd el Wahâb much on the same bold principle which had induced Mohammed to condemn the use of wine. The province of Nedjd became the chief seat of the Wahabee power. Under the last Saoûd (a very handsome man, whom the Arabs called Abou Showareb, or the Father of Mustachios), it reached its greatest extent. Like the early caliphs, he administered justice in person to great part of Arabia. The Wahabees, in the first twenty years of this century, extended their plundering expeditions to Syria, Irak, and Mesopotamia. In 1803 they took Mekka, and soon conquered the Hidjaz. In 1809 Mehemet Ali, the pasha of Egypt, began hostilities in Arabia; and in 1812 the Hidjaz was reconquered. Saoûd died in 1814, and was succeeded in his political and religious authority by his son Abdallah, under whom the Wahabees were subdued by the lieutenants of Mehemet Ali. But the Egyptians were unable to maintain the supremacy which they had obtained. Gradually the Wahabees regained their influence in the central parts of Arabia, and the Egyptians and Turks were driven back to the Hidjaz. But for many years no authentic information respecting the condition of this remarkable sect reached Europe. The first detailed intelligence about them was conveyed in Palgrave's *Travels in Central Arabia*, in 1865. That remarkable explorer found them established, under their blind Ameer, Feyzul, at Riadh, the modern capital of Nejd, maintaining a theocratic government of the most austere kind, and controlling by their arms and their example the chiefs of great part of the peninsula. His account was in the main confirmed by that of Lieut.-Col. Pelly, who visited Riadh as an agent of the British government of India. Their power seems still on the increase, their chiefs having of late obtained paramount influence in Oman and along the shores of the Persian Gulf, while numerous fanatical Mohammedan bodies, congenial in spirit with the Wahabees if not actually allied to them, have become prominent even as far as the borders of British India. (Burckhardt's *Travels in Arabia*; Burckhardt's *Notes for a History of the Bedouins and Wahabys*, 1830.)

Wahl Capitulation (Ger. wahl, *election*). In Modern History, the covenant entered into by an emperor of Germany with his electors on the occasion of election; by which he obliged himself to respect the liberties of the empire and of the diet, to surrender no portion of the empire, to preserve in vigour the stipulations of the peace of Westphalia, &c.

Waif (from the Saxon wafian, *to abandon*). In Law, goods stolen and abandoned by the felon, were so termed, and were forfeited to the king, or lord of the manor having the franchise of waif; but if the owner made fresh pursuit after the felon and apprehended him, or gave evidence whereby he was convicted, within a year and a day, he was entitled to restitution.

Wainamoinen, Epic of. This poem entitled Kalewala, and comprising a theogony not unlike that which bears the name of Orpheus, has been recently collected from the Finns, among whom it had been preserved wholly by oral tradition. It equals the *Iliad* in length and completeness; and in Professor Max Müller's opinion possesses merits which admit of comparison with those of the *Iliad.* It is further noteworthy as retaining the agglutinative type of languages, although at first sight it may be thought to have entered the inflectional stage which characterises the Greek and Sanscrit. (*Lect. on Language*, first series, ix.)

Wainscot. In Architecture, the framed lining in panels with which a wall is faced.

Waist (Welsh gwâsg). The part of the upper deck between the fore and main mast.

Waits (probably akin to Ger. wacht, *a watching* or *waking*). The popular name for the music played in our streets on the nights of the Christmas holidays. (*Archæol.* vol. ii. p. 66.)

Waiver (from *waif*). In Law, a term used to signify a party's declining or refusing to accept or to avail himself of something; as an estate, or of irregularities in legal proceedings.

Waiwode. In the Turkish empire, the governor of a small province or town.

Wake (Ger. wachen, Lat. vigilare, *to watch*). In popular usage, this word has the same meaning as *vigil.* The *wake* or *revel* of country parishes was, originally, the day of the week on which the church had been dedicated; afterwards, the day of the year. In 1536, an act of

convocation appointed that the wake should be held in every parish on the same day, viz. the first Sunday in October; but it was disregarded. Wakes are expressly mentioned in the *Book of Sports* of Charles I. among the feasts which should be observed. The wake appears to have been also held on the Sunday after the day of dedication; or, more usually, the day of the saint to whom the church was dedicated. In Ireland, it is called the *patron day*. (Brand's *Popular Antiquities*.)

WAKE. The track of a ship which she leaves in the water. A vessel directly astern of another is said to be in her wake.

Walchowite. A mineral resin, met with in rounded translucent masses, in the brown coal of Walchow, in Moravia.

Waldenses. In Ecclesiastical History, a religious sect, said to have derived their name from Peter Waldo, a merchant of Lyons, who preached what he regarded as the pure doctrine of the Scriptures about 1180. Historians have confounded them, on the one hand, with the VAUDOIS, who appear, although their history is involved in much obscurity, to be an older and separate people; and, on the other, with the Albigenses. They seem to have rejected an established succession of the priesthood, and the high Catholic doctrine of the sacraments; and are said in addition to have protested against oaths, warfare, lawsuits, and is obscure; and it may be said of them, as well as of other sects of the day, that they had little of the elements of permanence, the same opinions being continually promulgated afresh by new reformers, and then receiving new denominations. [ALBIGENSES; PETROBRUSIANS; VAUDOIS.] The reader may consult Milner's *Eccl. Hist.* for the most favourable view of these and similar sectaries; and, among many other authorities, Faber, *Churches of the Waldenses and Albigenses*; Mosheim, cent. 12; Jones, *Hist. of the Waldenses*; Milman, *Hist. of Latin Christianity*, bk. ix. ch. viii.; *Archæologia*, vol. ix.

Wales. Lines of planking in a ship's sides and quarters, thicker than the other strakes of plank. They occur at points where extra strength or curvature is required.

Wall (A.-Sax. weal, Lat. vallum). In Architecture, a body of stone, bricks, or other materials, enclosing a space, or carrying superincumbent weights, or serving both these purposes.

WALL. In Horticulture, a fixed structure for the purpose of improving the climate of plants by shelter, by supplying heat, and by exposing them to the influence of the sun.

Wall Eye. The popular name for the disease called GLAUCOMA.

Wall Knot. [KNOTS.]

Wall Plate. In Architecture, a piece of timber lying on a wall, on which girders, joists, and other timbers rest.

Wallflower. The popular name of one of our sweetest spring flowers, called by botanists *Cheiranthus Cheiri*.

Wallis' Theorem. Under this name the following remarkable expression for the ratio π of the circumference to the diameter of a circle is frequently referred to:—

$$\frac{\pi}{2}=\frac{2^2 \,.\, 4^2 \,.\, 6^2 \,.\, 8^2 \,.\, .}{3^2 \,.\, 5^2 \,.\, 7^2 \,.\, 9^2 \,.\, .} \text{ ad infinitum.}$$

John Wallis, the discoverer of this theorem, was born in 1616. His *Opera Mathematica* were published at Oxford in 1699.

Wallower. In Machinery, this term is used synonymously with *lantern* or *trundle*. [LANTERN WHEEL.]

Walmstedite. A Mineralogical synonym of Breunnerite (native carbonate of magnesia), after the Swedish chemist Walmsted.

Walnut (A.-Sax. wealh-hnut, Ger. wälsche nuss: wälsch in German means originally *a foreigner*; the word was applied especially to the Italians, and hence *walnut* means the *foreign* or *Italian nut*: Max Müller, *Lect. on Language*, second series, viii.). The fruit of the *Juglans regia*, a noble tree, which is also valued for its timber. Besides being eaten when ripe, walnuts are pickled while in the green soft state.

Walpurgis Night. The night of the festival of Walburga, niece of Boniface, the apostle of the Germans. This feast (May 1) is a common day in Germany, like Lady-day in England, for the commencement of leases, &c. It is also known as the day on the eve of which, according to popular superstition, the great witch festival is held on the summit of the Brocken, in the Harz Mountains.

Waltz (Ger. walzen). The name of the German national dance, and also of the species of music by which it is accompanied. Bohemia is said to be the original home of the waltz, whence it soon spread into other parts of Germany, and all over the Continent; and within the last few years it has become naturalised in England.

Wampee. The Chinese name for the fruits of *Cookia punctata*, highly esteemed in China and the Indian Archipelago.

Wampum. The American Indian name for shells used as money, or as a medium of commerce. These shells are run on a string, which is used as a belt.

Wapentake (A.-Sax. wæpentac). A territorial division in use among the Danish inhabitants of England: from wapen, *a weapon*. Yorkshire is subdivided into wapentakes instead of hundreds.

Wapiti. [ELK.]

War (A.-Sax. wær, of which the French form is guerre). In International Law, war is said to be *public* when it is a contest, by force, between independent sovereign states. A civil war is regarded by Grotius as *mixed* in its nature; being, according to him, public on the side of the established government, and private on that of the portion of the people resisting its authority. Public war is said to be perfect when one whole nation is at war with another, and all the members of each are authorised to commit hostilities mutually, subject only to the general laws of war. An *imperfect war* is limited as to persons, places, and things: to which class are referred by some

the hostilities of the United States against France in 1798; the hostilities between England, France, Russia, and Turkey, in 1827; and, if the usages of civilised nations could well be cited in such a case, our hostilities in China.

Formal declarations of war are now out of use: the latest example is said to be that by France against Spain, at Brussels, in 1635, which was announced by heralds. War is now usually preceded by the publication of what is termed a MANIFESTO; and the permission of REPRISALS is usually the last step short of actual hostilities and preceding them. The immediate effect of the commencement of hostilities would appear to be, on principle, the liability of all property belonging to subjects of one of the belligerent parties within the dominions of the other to seizure and confiscation; but many exceptions have been introduced by the practice of civilised states. (Grotius, *De Jure Bel. et Pac.* lib. iii.; Vattel, lib. ii.; Phillimore *On International Law*, vol. iii. ch. iv.) In former times it has been the regular practice in Great Britain to seize and condemn, as droits of Admiralty, property of the enemy found in our ports at the commencement of hostilities; but at the commencement of the Russian war, in 1854, the enemy's merchant shipping were allowed six weeks to depart in, and various other changes and relaxations were made. Trade, and every species of contract between subjects of belligerent states, is in general unlawful, although often authorised for particular times and purposes. Subjects of hostile states, *domiciled* in the enemy's country, have been held liable to reprisals; but not, it is said, mere travellers or temporary sojourners, though Napoleon on the renewal of hostilities in 1803 seized all English subjects then sojourning in France. In 1854, Russia, France, and England respectively accorded protection to resident enemy's subjects.

The rights of war are such as arise in times of hostilities: 1. Between enemies; 2. Between neutrals. As between enemies, it is a general law that subjects of a hostile state who are not in arms, or who have submitted, may not be slain. The killing of prisoners is justifiable only in very extreme cases. The usage of exchanging prisoners is now general, but was firmly established only in the seventeenth century; and it is not now considered obligatory. As to property, that belonging to the government of the vanquished nation belongs to the victorious state, wherever it is found; but private rights are unaffected by conquest, with the remarkable exception of private property when at sea, which is by general usage held lawful prize. The immunity of private property on land, however, is of a qualified nature only; generals have frequently laid waste hostile territory, as far as convenient for military operations and sometimes without this excuse, and contribution of money, food, &c., for the support of an advancing army and other military purposes, have also been required, as was done by Napoleon, and again by Prussia in her war with Austria in 1866. Acts of hostility are lawful, according to the modern usage, only when committed by those who are authorised by the express or implied command of the state; such as the regularly commissioned military and naval forces of the nation and all others called out by the government in its defence, as well as persons spontaneously defending themselves in case of necessity. Irregular bands of marauders are therefore denied the rights of war, and are liable to be treated as banditti; but this distinction is generally observed only so far as suits the belligerent's purpose. For private citizens taking up arms, although in obedience to proclamations, are constantly liable to be treated as marauders; as by the French in the Peninsular War, and in many other cases. For the rights of war as to neutrals, see NEUTRALITY. (*Oxford Essays* 1856, 'Growth and Usages of War;' Kent *On International Law.*)

War, Art of. In its simplest form, as seen among savage tribes, war always involves some artifice in addition to the mere open application of brute force. To steal unperceived upon the enemy, and attack him unprepared with the best weapons at command, is the first step in the developement of the military art, and as, from the earliest times, the passions of men have given rise to war, the desire of success has led to the improvement of this art, side by side with the progress of the other arts.

For some notice of the ancient systems of warfare, the limits of this work compel us to content ourselves with referring the reader to the articles HASTATI, HOPLITES, LEGION, MERCENARIES, PELTASTS, PHALANX, PRINCIPES, TRIARII, TURMA, VELITES; and also to Guischardt's *Mémoires Militaires sur les Grecs et les Romains*; Guibert's *Essai Général des Tactiques*; and Dr. Smith's *Dict. of Greek and Roman Antiquities*, art. 'Exercitus.'

When the Western Empire was overthrown, and the whole of Europe overrun by wild hordes of barbarians, each man was allowed a share of the conquered lands as a reward of his past military service, in return for which he was bound to future service. From this practice sprang the feudal system, and, during its continuance, war, as an art, seems to have become almost extinct. Petty wars between small rival chiefs, with incursions into neighbouring territories, formed the only military exploits of the earlier ages of feudalism. Then came the Crusades, in which army after army, ignorant of military science, and utterly deficient in organisation, melted away through the lack of unity, concert, and design. The same want of organisation is visible throughout all the wars of the period. The armies of the time seem to have been only an assemblage of knights and barons with their retainers, living on the territory under invasion, making desultory attacks on castles, or occasionally drawing up their motley forces in order of battle, and then charging in a grand mêlée. Strategy and tactics, as sciences, did not exist. Often utterly ignorant of the enemy's position, and

seldom knowing anything of the features of the country in which they were campaigning, the opposing commanders either agreed upon the place of battle, or left it entirely to chance. The chronicles of Froissart furnish many amusing instances illustrating this state of affairs. The only attempt at formation seems to have been to place the archers in front, to open the battle, the men-at-arms afterwards dashing into the thick of the fight with swords and axes.

No attempt was made to supply an army with provisions for a long campaign, from dépôts at a safe distance. Such a task was beyond the means of any feudal monarch; he could do no more than raise taxes and loans to set the army in motion, and then leave the war to maintain itself. But in course of time the power of the nobility declined, and in some cases became extinct; in others the king, by levying taxes on the people, surrounded himself with a standing army of trained and disciplined troops. Then arose a competition in warlike efficiency, heightened by the recent invention of gunpowder. For a long time the application of this invention had made but slow progress; but, in the time of Charles the Bold, field artillery had attained to considerable value; and the standing army of this sovereign proved itself so vastly superior to the feudal levies, that others soon followed his example, and standing armies of paid troops became the only forces employed.

The great wars of the Netherlanders with Spain at the latter part of the sixteenth century brought about great changes in organisation and tactics, but the method of fighting in deep columns or masses characteristic of all the previous periods was still retained. Then came the Thirty Years' War, in which Gustavus Adolphus inaugurated a new system of tactics, and fought with lines of infantry six deep against the solid masses, thirty deep, of Tilly and Wallenstein. He also formed his cavalry in three ranks only, and associated them with light guns.

After the Thirty Years' War came the wars of the French in Italy, in Germany, and the Netherlands, lasting for a century till the peace of Westphalia in 1738. At this time the efficiency of artillery, and the improved state of the roads and of transport, rendering the movement of guns comparatively easy, caused the art of fortification to be much improved. From the time of Albert Dürer, improved methods of fortifying towns had been applied by successive engineers; but the genius of Vauban during the wars of Louis XIV. increased the resisting power of fortresses to a marvellous extent. An advancing army, dependent upon its communications for supplies, could not safely pass by one of these, and thus the wars of Louis XIV. were but a series of sieges, and Marlborough's sieges far outnumber his battles.

During all this time the military machine was growing more manageable, and Frederick the Great of Prussia in his Silesian wars, taking advantage of the great mobility of the army, which had been drilled to perfection by his father, preferred to *mask* or observe fortresses with a small detachment of troops, and fall with his rapidly moving troops upon the slow bodies of the enemy.

Under Frederick the Great, the army was an aggregate of battalions; when assembled in the field it was itself the integer, and any detachment a fragment. The great success of this commander lay in watching his enemy, and, from the flexibility of his army, taking advantage of any error or unguarded movements; then falling rapidly on them, and especially applying his great tactical stroke, of placing his line obliquely across the extremity of his adversary's line within striking distance, he ruined them before their slow masses had time to change front to oppose him.

The Prussian plan was speedily adopted by the other nations of Europe, but it was left to the Emperor Napoleon to introduce that system of organisation and tactics into armies, by means of which he overthrew the troops trained upon Frederick's system, possessing in his own army the superior mobility and mutual support of all arms, which had previously belonged to Frederick.

In the first wars of Revolutionary France, many small bodies of troops, acting independently, were spread along her whole frontier, and were made complete in all arms, and trained to manœuvre in concert; but there was want of unity in their movements, and this unity was only attained when Napoleon, in supreme command in 1804–5, abstracted the great mass of the cavalry from the divisions, and united the divisions into corps under a marshal or lieutenant-general, each corps being sufficient to act independently, and complete in all arms. He then held the reserve of chosen troops in his own hand, ready for the decisive blow. Possessing also, in the French, troops of more intelligence than precision of training, he employed them as skirmishers, thus commencing the employment of light infantry.

We have thus briefly traced the history of the art of war, down to the present time, when arms of precision have been introduced; and we now propose to sketch the principles by which the operations of war are guided.

An army, as now constituted, is a gigantic machine, composed in part of disciplined soldiery, divided according to the different arms, and commanded by a hierarchy of officers, and partly of a mass of necessary appurtenances required for the efficiency of the rest, such as food, ammunition, shelter, medicine, and clothing. Such an instrument must be constantly receiving repairs, and the stream of supplies to it must be unceasing, both of men and material. It must, then, as it advances into an enemy's country, or protects some portion of its own, have some fixed source from which to draw these supplies. This source is called the *base of operations*, and may consist of a frontier line, a group of fortresses, a harbour on the sea coast, or other position. Here the great maga-

zines must be so protected as to be safe from danger, and to afford a secure starting-point for an army, and a safe shelter if a retreat should become necessary. Thus, if France were at war with Germany, she would find in the Rhine, strengthened by fortresses, such a base of operations; if with Italy, she would collect her supplies behind the barrier of the Alps.

If an army lacks a secure base of operations, it is at any time liable to be obliged to separate in order to subsist, and then all unity and concert is lost. An instance of the evils of operating without such a source of supply is afforded by the duke of Wellington's correspondence after the battle of Talavera. Placing reliance on the promises of the Spanish government, he left his dépôts in Portugal, and marched into Spain. There he fought and won the battle of Talavera. But, though victorious, he could obtain neither food nor forage for his army, and was compelled to retrace his steps to Portugal, thus losing a brilliant opportunity of striking a blow upon Soult at Placencia, or upon Mortier in the centre.

It is necessary, however, not only to possess such a base, but to keep up the connection with it, for evidently if the connection be destroyed, the advantages of the base are lost. An army must, then, at the risk of danger and ruin in case of failure, so dispose its forces, that on every advance or retiring movement it may secure and hold fast the line connecting it with its base, which is called the *line of communication*. 'Two armies,' says Colonel Hamley, 'are not like two fencers in an arena, who may shift their ground to all points of the compass, but rather resemble two swordsmen on a narrow plank which overhangs an abyss, where each has to think, not only of giving and parrying thrusts, but of keeping his footing under penalty of destruction.'

This, then, may be laid down as the leading principle of war, a departure from which may involve ruin.

In order that the enormous stream of supplies may be uninterrupted, good high roads, such as are generally only the main arteries of a country, are indispensably necessary. The fatal results of having none but bad roads to connect an army with its base, is shown by our own Crimean experience, where seven miles of soft soil caused such fearful difficulties; and again in McClellan's despatches, the same fact is proved as regards the Yorktown campaign. Besides this, good roads enable troops to move so much faster, and with so much less fatigue, that their quality must be taken into consideration in forming any plan. That armies move sometimes on bad roads is true; but such movements as that of Napoleon over the St. Bernard, and Wellington's pursuit of the French in 1813, are only of brief duration, and undertaken only when a new and better communication with the base is open at their conclusion.

We must thus think of an army, not as free to move anywhere in the theatre of war, but as dependent on a line, which must be a good road, connecting it with certain secure magazines in rear. Next, an army must be considered as moving not only on one main road, but distributed in parts upon several roads. An army acting on the defensive will have to hold all those lines by which an invader could advance, in order to check his progress at any point, till troops can be collected in numbers sufficient to repel him. Thus it must be spread out over many roads, radiating from the point which it has to cover. An invading army must march by many roads, or the column would be of such a length that its head and each succeeding portion might be destroyed before the troops in rear could arrive to its aid.

Approximately, 30,000 infantry occupy about 5 miles on the road, 60 guns about 2½ miles, 8,000 cavalry, in column of fours, about 3½ miles, irrespective of intervals between the columns, of losses of distance, and of stores. McClellan, speaking of his advance from Washington, remarks, 'If I had marched the entire army (about 100,000 men) in one column along the banks of the river instead of upon five different parallel roads, it would have extended about 50 miles.'

The more good parallel roads, therefore, that an army can find, the more rapidly can it assemble in fighting order. But good lateral communications between the roads are essential, or one part of an army may witness the defeat of another portion, without being able to assist, as in 1796, where the Austrians advancing on both sides of the lake of Garda, were beaten in succession.

An army advancing in such a manner must not only, as it advances a long distance, protect the magazines at its base, and the communications to them, but must establish magazines on these lines. In an enemy's country, the commander will at once obtain by requisition supplies of food and stores, and will further collect in magazines the surplus resources, so as to reserve for the hour of need the supplies which he already possesses. He will place these magazines on several radii of communication, and as much as possible at the junctions of roads, always covering them with his army.

Thus the most important points to be observed in order to follow the operations of a campaign consist of: (1) the bases on which the contending armies respectively rely for supplies of men and material, (2) the main roads by which they approach each other as they advance from their bases, (3) the positions of their magazines on those roads, and (4) the positions of the fronts of the armies as regards their lines of communication, in all their changes.

Before beginning hostilities, one party will generally resolve upon assuming the offensive, the other the defensive. Occasionally, as in the Italian campaign of 1849, both parties simultaneously advance; but generally one will resolve upon standing on the defensive, either

for political reasons, as the Confederate States in the late American war; or for geographical reasons, as when Wellington held the impregnable frontier of Portugal in 1812 and 1813; or from its relative weakness, as with Denmark in 1864. The defensive army must, as already shown, be spread over a considerable space; it is easily supplied and if forced back retires towards its magazines; but these advantages are more than counterbalanced by those possessed by an offensive army, which can concentrate behind its frontier, and so descend in force on any point of the defender's line, the defender's movements being from that moment dependent on those of the attacking party. The defender must either oppose the enemy with smaller forces at first, or lose territory in order to fall back and concentrate. On the other hand, offensive war demands great resources; and the invader, advancing into an enemy's country, exposes a long line of communication to attack. But the balance of advantage generally remains with the army possessing the advantage called by military writers the *initiative*.

In assuming the initiative, it is necessary to select an object to be gained by the campaign; and since to occupy a portion of country is of little avail, the end aimed at is generally the occupation of an enemy's capital. It paralyses a country's trade, and is ruinous. But to be able to hold the capital is as necessary as to occupy it; and, for this purpose, the enemy's armies must be defeated.

Occasionally, as in the case of Sebastopol, some other town assumes a peculiar importance; but most commonly the possession of the capital is the desired end. It was so with Napoleon in his Austrian campaigns; with the Federals who operated against Richmond throughout the American war; and with the Prussians in their recent advance into Austrian territory.

Having decided upon the *objective*, as it is termed by military writers, the invading general must select the portion of country in which he intends to operate, i. e. the *theatre of war*. The convenience of different bases, the position of the enemy's forces, the roads, the proximity to the object, and the nature of the country, must all be considered. Not unfrequently political considerations complicate the problem. The necessity of covering the territory of allies, as was often the case in the Austrian wars against Napoleon, and with the Prussians in the campaign of Jena; or the necessity of guarding against a possible attack on a flank from a power whose intentions are doubtful, as was our case in the Russian war, when the Austrian course was uncertain, may compel a certain theatre to be chosen. It is here that a military autocrat, combining political and military power, possesses great advantages, in imparting unity of design to a campaign.

But the impulse and direction having been given to a campaign, we will suppose the formation of the military plans to be left in the hands of the general who is intrusted with their execution. The art of war is commonly divided into *strategy* and *tactics*. Strategy is the movement of an army in the theatre of war, and merges into tactics on the field of battle. All operations must ultimately rely for success on power of fighting; but strategy should so conduct an army as to give it a relative advantage when the collision occurs. If two armies advance straight upon each other face to face, as at Solferino, force and tactical skill must decide the day; but if one army has been so placed as to compel the other to fight in a disadvantageous position, the object of the strategist has been obtained. A general must consider how to increase the *probabilities of victory*, and also how to insure the most important *consequences from victory*. Two armies may be so placed that the chances of victory are equal, but the result of defeat to one may be the loss of its communications, and consequent ruin; while the other, if beaten, can retreat along its proper line. It is needless to say what an advantage the latter army possesses, and with what increased confidence it will fight. On the other hand, two armies may be equally sure of their communications, but one may be scattered, the other concentrated. Here, again, the general of the latter army has attained a strategical advantage. To combine both advantages is the triumph of strategy.

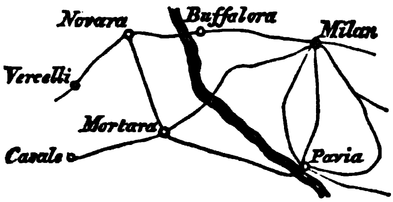
From the necessity of preserving a safe line of communications, it is evident that the great objects of a commander will be, while keeping his own communications guarded, either (1) *to menace or assail the enemy's communications* so as to force him from off his line and base; or (2) *to fall directly on the communications which connect the parts of his army*, and so disintegrate it and destroy it piecemeal, *by bringing superior concentrations on particular points of his front*. Of each of these we will speak briefly.

The way to menace an enemy's communications, and to push him off them, is so to manœuvre as to compel him to form up his army parallel to the line of communication, and in this position to accept battle. For when thus placed, his retreat will not cover his communications, but be at right angles to them; and his communications being thus seized, his army will be cut from its base. If one of two armies is operating on a front perpendicular to its line of communications, while the other is in the position described with *its front formed to a flank*, the advantage is entirely with the former; neither does it matter whether the armies are operating with extended fronts, or concentrated; nor if the front is extended, and the space between wanting in defensible positions, is the distance of the front so formed to a flank from its line of communications of any great importance.

But unless the commander thus manœuvring should succeed when the decisive conflict is fought, he will gain nothing by his strategy. Thus Marmont, in 1812, forced Wellington

to accept battle at Salamanca in this position; but Wellington won the battle, and Marmont reaped no success from his skilful movements. On the other hand, when, in the campaign of 1849, the Austrians under Radetzky, advancing from Pavia through Mortara, forced the Sardinian army under Chzarnowsky to form front at Novara parallel to its communication

Fig. 1.



with its base through Vercelli, the Sardinians, defeated at all points, were pushed off the Vercelli road, and pursued northwards by the Austrians. The result was the abdication of the Sardinian king, and a peace in favour of Austria.

Sometimes it may happen that both armies may form front to their flanks, either from confidence of the issue of a battle on both sides, or for other reasons. It will almost invariably be found, that when two armies are manœuvring against each other's communications, that army whose communications are most immediately threatened will abandon the initiative, and conform to the movement of the adversary. It was so in the campaign of Novara, already cited, where the Sardinian army was striking at Milan, when it felt Radetzky's grip closing on its communications, and at once turned to meet him. It was so also in 1806, when the Prussians, intending to fall on the centre of the line of the Maine and cut off the French, found the latter advancing to intercept their communications with the Elbe. The battle of Jena was fought by both armies fronting to their flanks; and the decisive defeat which the Prussians sustained drove them from their line, and compelled them to retreat in different directions, till ultimately their ruin was completed by the successive defeat of all the portions of their army, and the capture of their fortresses.

Again, the conformation of a base may enable the army possessing it to force its enemy to form front to a flank, as was notably the case when, in 1800, the French possessed the angular base formed by the Rhine in its course from Schaffhausen, by Basle, the point of the angle, to Düsseldorf. This was due to the unscrupulous seizure of Switzerland by Napoleon. The Austrians, whose main body was concentrated about the sources of the Danube, were forced by Moreau, advancing from the south, to form front parallel to their line of communications along the Danube; and, though not signally defeated, they lost the whole of the Black Forest.

Thus it appears that, by taking advantage of the direction of the roads in the theatre for his manœuvres, as at Novara and Salamanca, or by a prompt assumption of the initiative, as at Jena, or by aid of the configuration of the frontier line, a skilful commander may force his enemy to form front to a flank.

But there are cases where a general, having succeeded so far in his manœuvres, has not been content with this, but has thrown his army across the line of his enemy's retreat. This was twice done by Napoleon, at Marengo and at Ulm, and once by Moreau in 1800 on the Danube. In making such a movement, an army must, however, form front either to its rear or to a flank, and so far be in danger. In that case the adversary may reverse the position.

Should the connection of an army with its base be by one road only, it has no choice, if that connection be intercepted, but to cut its way through. Generally, however, there will remain to it two other alternatives, viz. to attempt, by a march to the other flank, to evade a collision, or to march to one flank across the communications of the intercepting force. Of these three alternatives, if it choose the first, it may, by a victory, retrieve all; but a defeat is ruin. If it choose the second, it abandons territory without a blow. If it choose the last, it may, by seizing the enemy's communications, reverse the position; and this is generally the best course to pursue. The first thing for the commander of the army thus intercepted must be to concentrate his forces; the next, to move promptly with his entire army against the communications of the intercepting force. Should he succeed, he may retrieve the campaign. Thus if Melas, in 1800, had been more prompt in his movements, and if Mack, in 1805, had struck boldly at Napoleon's communications towards Nuremberg, much disaster might have been saved to each.

We will now pass on to those operations which have to do with the fronts of opposing armies, but not specially with their communications with the bases. It has already been shown, that troops must, in almost every case, move in long columns on roads. When in this formation, only the heads of the columns can be immediately deployed for action; and so, generally, the march of a force may be delayed and checked for a short time by a small force deployed in order of battle, which may be only a little superior to the heads of the advancing columns.

This is one of the most important facts in strategy; and, if skilfully applied, is invaluable to the commander. A retarding force should be drawn up in such a manner that the advancing troops cannot tell how small it is; they will pause to reconnoitre, and to deploy troops sufficient to be sure of success. And here the skill of the officer in command of the retarding force will be proved. He must occupy his ground to the last moment, so as to retard the advancing enemy as long as possible, but must retire when outnumbered in line, without fighting

a general action, and at the earliest opportunity he must repeat the manœuvre. In this way he may gain for the army from which he is detached most valuable time to prepare for action. It was thus that Ziethen retarded Napoleon's march on June 15, 1815, and by his defence of the several positions of the Sambre, Gosselies, Gilly, and Lambusart, delayed two columns, one 45,000, the other 64,000 strong, so that from morning till nightfall they advanced only four or five miles, although Ziethen himself had only two brigades, each about 8,000 strong.

Again, in following up a retreating army, a small force may often press upon the rear of a large force, for the troops which have been beaten will be disorganised, and their commander will not know how large the pursuing force may be. If, finding out the pursuer's weakness, he should turn, the pursuer will at once take up the part of a retiring and retarding force.

Thus we may assume that part of an army may, in this manner, *occupy* or *contain* a superior force of the enemy, who is advancing, and that a beaten army may be for a time pursued by an inferior force; and one other point scarcely needs demonstration, viz. that the course to be taken by parts of an army which have been separately defeated is to retreat in order to recombine.

Bearing in mind these points, we are prepared to consider those problems which arise where it is impossible, from geographical considerations, for one commander to strike at the communications with its base of the opposite force, without exposing his own communications to similar or greater risk. Such conditions must evidently frequently occur, and opportunities must then be sought in the relations which the fronts of the hostile armies bear to each other. The front of an army being, as we have shown, necessarily divided, opportunities must occur for pushing into the intervals of an enemy's front, and separating its parts. It was thus that Napoleon, in 1796 (the first campaign of his extraordinary career), broke in between the Sardinian army under Colli and the Austrian army under Beaulieu, and separated them; then leaving a small force to *contain* Beaulieu, he threw his whole weight against the Sardinians, and having forced them to a peace which gave him the fortresses of Piedmont, with the Mont Cenis route to France for future operations, turned his whole army upon Beaulieu, and forced him back across the Po.

Thus again, in 1809, he was engaged with the Archduke Charles advancing from the Inn to the Danube in strength equal to his own, and in comparatively close array; but he interposed the main French army between the parts of the Austrian front at Rohr, left Davoust with an inferior force to contain the Austrian right wing, and threw his whole force against the left wing, which he defeated; then detaching a force sufficient to pursue the beaten corps towards Vienna, he concentrated on his left for a blow at the Austrian right wing, which he defeated at Eckmühl, driving it northwards through Ratisbon; then again turning his main force, he pursued the left wing, and pushing out the Austrian garrison, occupied Vienna.

In these operations we see the immense advantage gained by concentrating an army between two divided portions of an enemy. 1. All communication between the divided parts is checked, and combination becomes impossible. 2. Either part of the separated army may find itself exposed to the blows of the full force of its antagonist, minus a detachment left to contain the other part. 3. By alternating such blows, the assailant may continue both to weaken his antagonist and to interpose between the parts. Under these circumstances the best course for the divided army will be to retreat for reunion, retarding the enemy on both lines; for, until reunited, it will be in no position to retaliate upon the assailant's communications, or to attack him in front.

But it follows, as a matter of course, that a force thus interposing itself between two parts of an enemy *must be strong enough to beat either part, after leaving a detachment to contain the other part*; otherwise it cannot expect success.

If an originally combined force is placed in such peril by its front being pierced, manifestly two independent armies, possessing no preconcerted plan of action in the event of separation, are in even a worse case if divided; and thus, for two armies to operate against a combined army by lines, where from distance or want of concert they are independent of each other, is to confer on the enemy an advantage greater than that which has been demonstrated to follow from interposing between the parts of an extended front, and that advantage will be such as to compensate for considerable inferiority of numbers. This is illustrated by the campaign in Germany in 1796, where the Archduke Charles was opposed to the two armies of Moreau and Jourdain; and by Napoleon, in a splendid manner, in his campaign of 1814. Again, the campaigns of Virginia, in 1861 and 1862, give examples of another form of the same operations, the grand principle in all these cases being that one concentrated army uses a retarding and inferior force on one side and brings a preponderating force into action on the other side. The operations of Jackson in Virginia, moving with wonderful rapidity from one side to another, will be fresh in the memories of our readers.

One instance of this concentration of an army against a portion of the enemy's forces, which we cannot pass by without comment, is the campaign of Waterloo. In this case, the English and Prussian bases were divergent, the English being based on Antwerp and Ostend, the Prussians on Cologne. Division was thus to them even more dangerous than in any of the previously named cases. Napoleon, breaking in upon their front, intended to separate them in such a way as to open the road to Brussels. He hoped to defeat Blucher's

corps in succession, before they could assemble, and, driving him back towards the Rhine, to hold him in check with a containing force, and throw his whole force upon Wellington. But he was held so long in check by Zieten, that Blucher's corps had united at Ligny before he could attack. Still they were defeated, and they retired during the night of June 16; and on the 17th Napoleon detached Grouchy's force in pursuit. Then, quitting the field of Ligny; with the remainder of his army, he joined Ney, who had fought the battle of Quatre Bras on the 16th, and threw the whole weight of their combined forces on Wellington at Waterloo. But Blucher, after Ligny, instead of retreating along his communications to his base, had taken the gallant and hazardous step of marching to join Wellington by a circuitous route, though Grouchy was descending directly on his communications. Grouchy's pursuit was wrongly directed, and he failed to intercept Blucher, whose troops arriving on the field of Waterloo, on the French flank and rear, while the English advanced in front, decided the action against Napoleon.

In this campaign, as in others, Napoleon adopted the plan which should always be followed where it is thus intended to break in on an enemy's front, and divide his forces. He divided his army into two wings with which to feel the enemy on either side, and a central reserve to reinforce either at discretion. Thus first he joined his centre to his right at Ligny; then leaving his right wing to pursue the Prussians, he joined his centre to his left for the attack upon Wellington. But he had scarcely sufficient force to count on success, even if Blucher had not succeeded in again combining with Wellington.

There is one other operation which we have not noticed, the case of dislodging an army by operating with a detachment against its rear, as Sherman repeatedly dislodged Johnston in Georgia, in 1864. This movement, involving separation of the attacking force, is dangerous, and justifiable only when the front of a position is unassailable, and a movement against the enemy's flank with the entire army unsafe; or when the roads will not permit the entire army to advance in effective order, or when the separating army possesses divergent lines of retreat; but, in every case, *an army thus separating must be greatly superior in numbers*, or it exposes itself to almost certain defeat.

Both methods of strategical enterprise—against the enemy's communications and against his front—have now been touched upon. For an army strong enough to fight its enemy's whole force, action against his communications is, wherever safe and practicable, most desirable; and the enemy, when formed to a flank to resist such an attack, may perhaps be separated and destroyed piecemeal. Such a success would be the perfection of strategy. But if an army be weak, it should endeavour to break in and divide its enemy's front; for by a blow at his communications it would force him to concentrate, and so compel what it ought to prevent. Generally, to break the front will be found the most decisive and readiest method.

We have thus far discussed strategy only with reference to its general principles, and on the assumption that the theatre of war opposes no difficulties of a special nature. But a glance at a map will show that the theatre of war is generally a varied and irregular surface, crossed by rivers and mountain chains, and in some places studded with fortresses. To appreciate thoroughly the influence of these is one of the most important matters for the student. The character of a country, its cultivation, the direction of its chief rivers and mountain ranges, the lines of roads, the relations between the armies and the obstacles in the theatre of war, require close study in order that a plan may be resolved on, that the nature of the marches and encounters may be foreseen and provided for, and that the proportion of arms may be properly adjusted, as well as the nature of the supplies and equipment most necessary for the campaign.

The configuration of bases and frontiers will affect a campaign from its outset. We have already shown the advantage gained by Moreau in 1800, by the possession of the angular base formed by Switzerland and the Rhine frontier; and how the holder of this base is enabled to fall on the communications of a German army near the source of the Danube. Again, the local character of the Peninsula was most important. Wellington held an almost impregnable base in Portugal, which could be approached only by two lines, defended by Ciudad Rodrigo and Badajoz respectively. On the other hand, the French communications from Bayonne were always exposed to a flank attack by the English as possessing command of the sea; and the French were confined to that and one other bad line by the chain of the Pyrenees, through which these were the only outlets. Thus, too, in the campaign of 1866, the salient angle of the Bohemian mountain frontier afforded the Austrian army, if they had been prepared, an opportunity of issuing and penetrating the Prussian front, which was necessarily separated in Saxony and Silesia; while, on the other hand, it gave the Prussians a chance of striking at the Austrian communications, and forcing them out of the angle. Generally, with such a base, the advantage is with the side assuming the initiative, and greatest with the side holding the salient angle.

Obstacles (by which we mean obstacles possessing advantages for defence, and which cannot be passed by deployed troops) present peculiar strategical problems. A long line of mountains that meets an advancing army in front is not, unless especially steep, a very serious obstacle; nor should it be defended pertinaciously, especially at a number of points, for usually it can be turned, or penetrated by a variety of passes or paths. Its uses to the defender will be to retard the enemy's advance,

and to limit him to a few difficult lines of supply when he has passed it. The best plan to defend it is merely to hold the passes with detachments, posting the army where it can force the enemy issuing forth to form front to a flank.

A river, on the other hand, allows the defenders to deploy and bring powerful converging fire on the column attempting to cross; but there are so many passages across a long river, and it is so easily bridged over, that the difficulty of guarding it becomes very great.

The conditions already arrived at as regards breaking the front or turning the flank, apply equally to the passage of a defended river. In case of its flank being turned, it is better that an army defending a river should, if possible, cross and strike at the enemy's communications in return; but such a course is seldom adopted, and if he remain on his own bank, the defender's most effective action will be against the outward flank of the turning force. The passage of a river at points deliberately defended is, however, difficult, and costly to the assailant. Thus, at La Rothière, in 1814, the Austrians could not pass the bridge throughout the whole battle; and at Fredericksburg, in 1862, Lee routed the Federals upon crossing the Rapahannock. Passages are generally made by stratagem, examples of which may be found in Moreau's passages of the Rhine in the enemy's front in 1796 and 1797; while for examples of passing a river on the flank of the defensive army, we may select Wellington's passage of the Gave de Pau in 1814, and the French passage of the Ticino in 1859.

The true use of obstacles which cross the assailant's path is to give their possessor increased power of manœuvring offensively, and of taking the enemy at a disadvantage; but they have defensive uses also, viz. to cover a flank movement; to afford opportunity for rallying a beaten army, as the Mincio did after Solferino; to enable part of an army to hold a forward line and protect territory till reinforcements arrive; to cover a concentration in rear, as Zieten did on the Sambre; or, lastly, to cover a retreat, a use to which they were most skilfully applied by Massena retreating before Wellington in 1811. But to attempt to hold them entirely on the defensive will only be to give aid to the enemy, to whom they will afford opportunities of displaying strategical skill. An advancing army, wresting a river from its defenders, will make use of it as a sort of advanced base, and thus secure its line of communications.

While direct obstacles are at once seen to interpose difficulties and delay in the way of an advancing army, there is another class of obstacles, the effect of which is not so obvious, viz. those of which the general direction is parallel to the path of the advancing army. Such an obstacle was the ridge of the Monte Junto in Portugal, at right angles to the line of Torres Vedras, which compelled both Massena and Wellington to operate by one side of it only, under peril of suffering the penalties to which a divided army is always liable. A chain of mountains running in such a direction may also be used as a screen for a movement against the enemy's communications, as in the Leipsic campaign. When a river forms an obstacle of this nature, it often exercises great influence on a campaign. An advancing general cannot venture to leave behind on his flank a defended passage of a river of this kind, unless he leaves a covering force equal to that of the enemy; otherwise he is in danger of his flank and rear being attacked. It is evident, then, that the advancing army must possess greatly superior numbers. Its risk is, however, lessened if the defenders are in possession only of one bank; and hence it is, as the Archduke Charles points out, that the first care of a general posted on the Danube should be to establish a double bridge-head, i. e. a work on each bank, securing the passage of the army.

In fact, an obstacle of this kind confers on its possessor all the advantages of the angular base augmented, because extending to both sides of the theatre. It presents a succession of points which must be either attacked at a disadvantage, or turned under protection of a covering force, and either course requires superior numbers. The army that advances offers an advantage to its adversary, who, to profit by the position, must take post near a point of passage, and await the movements of the advancing force.

Great additional complexity is introduced into the question of the influence of rivers of this class, when two or more flow in the same general direction and converge. If the operations lie altogether on the outward bank of one of two such rivers, the other loses all its immediate importance. But it may happen that the most direct routes lie between such rivers, and, in the windings of the streams, pass from one bank to the other. An army advancing by these routes must sometimes have to force a passage at a known point, and, while moving on the inner bank of one river, it will be exposed in flank to the direct attack of an enemy who makes the other river the pivot of his stroke.

There remains one class of obstacles of great importance. When armies were slow and cumbrous bodies, fortresses gave great strength to frontiers, exposing the convoys of troops, as they moved along the main roads, to sallies from the fortresses placed on these roads. But they were costly defences, swallowing up huge bodies of troops; and when armies became more mobile, fortresses were generally *masked* by a detached force left in front of them: nor do they now prevent armies from marching past them. Thus, in the German campaign of 1866, the Prussians masked no less than five fortresses, Königstein, Theriesenstadt, Josephstadt, Königratz, and Olmütz.

But fortresses have great uses if properly situated, and if impregnable to open assault; for

they can be used as temporary bases round which an army may safely manœuvre. Situated on rivers at points where the main communications cross, they are most valuable. If situated astride of direct obstacles, they give security to the front or flank of a defending army, enabling it to force the assailing army to fight with a front parallel to its communications. Placed astride of rivers, parallel to the advance of an enemy, they form a pivot for a flank attack, or defend a passage, as may be required.

As to their position on frontiers, an open frontier is best guarded by a few great fortresses, situated on the most direct lines to the capital. If the issues of a frontier are few, the fortresses guarding them become of immense importance. For this reason Wellington made such repeated attacks upon Badajoz and Ciudad Rodrigo, as commanding the only two avenues between Spain and Portugal.

It is difficult to overrate the importance of fortifying a capital. Had Paris been fortified, the campaign of the Allies in 1814 might have had a very different termination.

We have thus sketched the main features and principles of strategy, the grand elements of which remain unaltered by the increased civilisation of the age. But the advance of civilisation, increased wealth, more rapid and certain communication, will enlarge the sphere of strategy, and will make greater demands on the intellect of the commander. Steam, telegraphs, railroads, and commerce increase the advantage which superiority of conception always claimed; just as the growth of Europe in agricultural wealth and the improvement of her highways enabled Napoleon and his contemporaries to use a strategy which to Frederick and Marlborough seemed too bold, or was applied by them only in countries perfectly friendly, open, and well tilled beyond the custom of their time. Nor let us doubt that mankind will be great gainers by the change. Whatever increases the rapidity with which the great machines called armies are worked, and causes the fate of a war to be sooner declared, will diminish the suffering caused by the struggle to the populations. The more perfect the system of supply and conveyance, the more striking the strategy, by so much the less will it be worth the while of generals to prolong their operations for the purpose of subsistence, and of governments to hold out for unreasonable terms in the hope of wearying out the foe. The tendency of strategy being evidently then, in this direction, and its theory unchanging, while in practice it becomes bolder with increased means, it remains to trace the developement of the tactical part of warfare under the most modern conditions, i. e. to see what improvements have been made during the past sixty years in the use of the various arms in face of the enemy. (*Edin. Rev.* Jan. 1866.)

If the operations in a theatre of war have undergone great and remarkable changes since the feudal times, no less radical and complete have been the alterations in the method of conducting the movements of armies on the field of battle.

When soldiers were armed with pikes, axes, and shields, the best formation was that of deep columns, which possessed momentum, and were able to withstand the charges of men-at-arms. But on the introduction of firearms (as only two ranks can discharge their pieces), a line was generally formed three deep, the third line loading for the others. Deployment into long lines was a matter requiring precision of drill, and in the time of Eugene and Marlborough was but slowly effected. Positions were chosen deliberately, and two armies drew up and attacked in parallel order. Manœuvring, as we call it, was almost unknown. Marlborough's great skill lay in detecting the weak parts of the opposing line, and attacking them with heavy blows. It was thus that at Blenheim and at Ramillies he pierced the enemy's line. The armies of Frederick, better drilled, as we have already shown, were able to manœuvre to a flank, and thus he contrived to outflank his enemy, and place his line within striking distance obliquely across the extremity of his adversary's line. His army was not an aggregate of corps, divisions, or brigades, each capable of acting independently; it was itself the unit. It camped and fought in two lines; it moved to a flank in two columns, ready at a moment's notice to wheel into line, and to the front in four columns ready to deploy. At Prague it was by this flank movement that he defeated the Austrians, turning their right, and then piercing the centre. The army whose flank is thus turned, will naturally (as on this occasion the Austrians did) try to throw back the turned flank; and thus it is formed in a salient angle. This is a dangerous formation, as the whole force of the assailant may be brought to bear on one flank; the advance of either flank causes a gap at the angle; the face assailed will be liable to be turned on both flanks; the fire of the assailant's artillery enfilades one or both faces; and the defeat of the assailed wing compromises the retreat of the other.

Seeing, then, the advantages of turning a flank, the French at Rossbach in 1757 tried to take the same advantage of Frederick, but failing utterly, they displayed the fact that an army attempting openly to outflank another, but not succeeding in turning the flank, and finding its enemy drawn up across its path, is itself outflanked; so that, under ordinary circumstances, such an enterprise will be futile and disastrous, for the army against which the movement is directed has a less distance to move.

The Prussian system of manœuvres was now adopted throughout Europe; and, as we have already briefly mentioned, remained in force till Napoleon's distribution of an army into corps, each complete in its own staff, hospital, and commissariat, each able to be treated as a separate army for movement and supply, each able to be separately handled on

the field of battle, introduced not only great changes into strategy, but into tactics. 'An organisation by corps-columns moving independently, with connecting detachments between them, changed where convenient into lines, and covered with skirmishers to shake the enemy's order and keep him out of range. Cavalry less exposed than of old, yet partly used to connect the movements of the infantry divisions and guard their flanks—reserves increased to a large proportion of the whole force, and strengthened by a powerful artillery—the latter arm greatly augmented and placed more in mass—a careful occupation of natural obstacles in front by detachments, whilst the bulk of the divisions are sheltered where possible from the enemy's guns—such are the normal rules on which orders of battle were formed down to the time of the Third Napoleon.'

Let us now consider briefly the functions of the different arms, and the formations by which each attains its fullest influence. Modern infantry exercises its influence in battle either by firing on the enemy or charging. The first is a defensive mode of action; the second essentially offensive.

Cavalry attains its power by the impetus of its charge, and a certain distance must interpose between its front and that of the enemy to be assailed, in order to give to its advance both perfect order and great momentum.

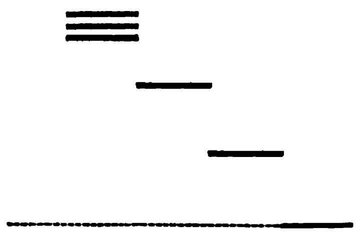
Artillery possesses the power of firing at longer range, and with more destructive projectiles, than infantry. It should begin to fire beyond the effective range of small arms, but not so far as to be practically out of range; and it should fire diagonally or transversely against lines of troops. Against columns it may fire either in front, in flank, or transversely.

In studying the formation of infantry, it is evident that long deployed lines will give the greatest effective fire; but in the advance columns will be more steady, and less liable to be broken, while they are also more able to obtain shelter. On arriving near the enemy, they can either deploy and engage in musketry fire, or charge with their whole force.

In Frederick's time the well-drilled Prussians generally attacked in line; but the republican and imperial armies of France were trained to attack in column, the front being covered by clouds of skirmishers. The most usual formation was line of columns of battalions; sometimes a mixture of line and column. And as it is probable that columns would never charge a line which stands firm, but deploy and try the effect of their fire, small columns easily deployed will be most effective. When the action has gone on for some time, when the fire of artillery has had its effect, and the defensive line is no longer intact, the attacking force, feeding its line from its supporting columns, will endeavour to quench the enemy's fire, and finally launch its columns to the assault.

Thus, then, as we have shown the open turning of an enemy's flank to be a perilous move, the great object of modern battles is to bring a superior force to bear at a certain point of the battle-field. The design is screened by false attacks, by features of the ground, by the advance of skirmishers. And as the attacking force must be strengthened at the expense of some other part of the line, that weakened part must be kept out of the engagement. *Echelon*, or *stair* formation, is very favourable to this, allowing the weakened or exposed flank to be retired out of

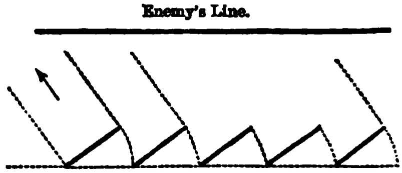
Fig. 2.



the way, while line may be formed on any front, or a new front of échelons may be formed by a simultaneous wheel. The head of the formation may be reinforced for attack; if successful, the remaining échelons come up and form line on it—if opposed strongly, they successively reinforce it—if defeated, they cover its retreat. Sometimes oblique échelon is em-

Fig. 3.

Enemy's Line.



Original Line.

ployed to gain ground to a flank in advancing. If columns are successful in the attack, and pierce the opposing line, they deploy right and left, rolling up the enemy's exposed flanks, while through the gap cavalry and fresh bodies of infantry pour in to break the second line.

As regards the formation of cavalry, it should be stationed far enough behind the object to be defended to allow it to obtain the proper momentum during its advance; and as it has to seize special fleeting moments for its attack, it should be kept formed in order of attack. It must never fight in close column; but a series of lines may with advantage charge on a square or column, the succeeding lines attacking in turn, as the preceding lines, failing to penetrate, wheel outwards.

Cavalry combined with infantry may attack in flank the enemy's column, already engaged in front by the infantry; the attacked troops must in such cases form squares, thus giving the line of infantry attacking them a great superiority of fire. Cavalry charges, unless supported by infantry, are indecisive, for the

infantry are required to keep what the cavalry have gained.

Artillery must, of course, be formed in line, though that line need not be perpendicular to the enemy's front. Its fire is most effective when down a gentle slope, or along a plain over which the guns have a certain command. Combined with cavalry, horse artillery advances rapidly, opens fire, and ceases only when its front is masked by the advance of the horse; and in retreating, it similarly halts, fires, and then gallops on to overtake the retiring cavalry. In these cases, it ought always to be on the flanks of the cavalry, so as to be out of its way. Cavalry, without artillery, is powerless for defence; with good artillery it may be valuable for attack, and itself protected. Artillery should not be placed in rear of other troops, for the rush of shot over their heads would make them unsteady. Nor should infantry be placed in rear of artillery, but on or in rear of the flanks to protect the weak points; the guns can protect their own front. Artillery, when on the defensive, will fire at the attacking columns; when on the offensive, partly at the enemy's artillery, to prevent its destroying the advancing columns.

Such, then, being the functions of the three arms and their relations one to the other, we may now consider the formation of the line of battle, and the occupation of the ground. The line of battle shouid be a disposition on a great scale, of the three arms, for their effective individual action and mutual support.

And, first, it is necessary to gain a clear idea of the proportions of troops to space. Foot soldiers standing in the ranks occupy each 21 inches of lateral space; thus 12 men occupy 7 yards. Cavalry occupy each man and horse 1 yard laterally. Guns 19 yards from muzzle to muzzle, with 9½ yards on each flank. Apply this to larger bodies of troops, and we get 6,000 infantry in simple line two deep occupying about a mile: a regiment of 6 squadrons of cavalry, with intervals between squadrons, about 350 yards; a battery of six guns, 114 yards.

Allowing space for officers, intervals, and two batteries of guns, a division of 12,000 infantry with 12 guns, in two lines, each two deep, will occupy, with battalions in front as skirmishers, about a mile in length. As this distance is too long to be defended by guns from one flank only, its guns should be disposed on both flanks. The cavalry also should be on the flanks of the whole line, for if it were placed between the divisions in column, it could not deploy without masking much infantry fire, and if in line, all that space which it occupies would have no fire to oppose to the enemy. Hence it is generally placed in rear of the flanks of the line of battle, though a small number of squadrons may be advantageously placed in rear of the first line, so as to act between the divisions if occasion should arise.

The second line should be near enough to the first to afford support, but not so near as to give the enemy's artillery a double chance. A distance of from 200 to 300 yards is generally considered best. The most convenient formation for this line will be battalions in double or single column of companies.

As regards the choice of a position on which to form line of battle, it must be remembered that although a steep range of heights may be so strong as to defy superior numbers, the difficulty of making a counter attack from it will be proportioned to its inaccessibility. Cavalry and artillery will here be of little or no value. Such a position, then, may suit a general wishing to act purely on the defensive, and delay an enemy; it will not avail for measuring strength with him. The best ground for this will be such as obstructs the assailant but not the defender, e. g. the crest of a slight slope overlooking a plain along which the enemy must advance. A river in front, if the passages are in the defender's hands, may be useful, provided the assailant's bank do not afford him concealment for a turning movement.

An impassable obstacle extending partly along the front may shelter guns, but will render other troops posted behind it useless in an action, and so is bad. Again, to occupy a position intersected by an impassable obstacle, is only to offer two halves of the army in succession to the enemy's whole force. But if the assailant can be compelled to advance on each side of such an obstacle, it is a great advantage to the defender. Again, the ground in front must not afford shelter to the advancing troops of the enemy, or even to his skirmishers.

Defensible points, such as hamlets, farms, churches, &c., within easy distance of support, will increase the defender's strength; but unless they are within cannon-range of the line, and easy of access from it, it is better to destroy than hold them. Such points in the actual line of battle are very disadvantageous, for they break the line, and if once gained by the enemy, give him a footing in a dangerous position. In arranging a line of battle, it is desirable to protect the flanks, not by insuperable obstacles, which hamper the defender, but by such defensible posts as we have named.

The student of tactics cannot do better than study the disposition of the troops at Solferino, at Austerlitz, and at Waterloo, of all which battles full accounts have been handed down. Our space forbids our entering upon them here. Colonel Hamley draws from them the following deductions:—

'That in ordinary circumstances the formation in two continuous lines prevails, the exceptions being: (1) refused portions of the line, where the formation may neither be continuous nor on two lines throughout; and (2) portions of the line reinforced for a special purpose, generally for attack.

'That columns are the only formation for the advance and the attack, with the single exception of troops in line, which, having awaited the attack and compelled the hostile columns to

pause, charge, in their existing formation, over the short interval that separates the bodies.

'That of the various kinds of columns for attack, battalion-columns have been most resorted to and most successful.

'That general attacks of either cavalry or infantry should be supported by the other arm, and preceded by a concentrated fire of artillery.

'That cavalry is not uniformly stationed on the flanks of the line of battle, especially when a flank is otherwise supported (as at Austerlitz); but that it should uniformly cover the flank of an attacking force which, by advancing, is separated from the rest of the line; and that, when the attack assumes the salient form, a force of cavalry should be stationed near the angle, so as to fill the gap and operate on the flanks when the faces open outwards; and that, for these purposes, the place for great reserves of cavalry is near the centre.

'That artillery does not always occupy spaces in the general line—the exception being when the downward slope allows it to be posted in front of the infantry without giving double effect to the enemy's projectiles.

'That the proper use of reserves is not to keep them in hand till the last moment, but to consider them as a *disposable force*, ready to support any point, or aid the enterprises of any part of the line, at any period of the battle. Nevertheless, it is well always to keep a part of them fresh to the last; thus, at the close of the battle of Austerlitz, Napoleon had still untouched battalions ready for any effort; and the two battalions of the Guard which did not join in the last attack at Waterloo alone withstood the general wreck, and in any degree covered the retreat.

'The worst use, however, that can be made of reserves, is to fritter them away by repairing gaps and losses throughout the line: they should act as much as possible in masses.

'That, when divisions act together, they do not form the one the second line to the other; but that each division forms its own first and second line with its own brigades, while the brigades form partly in each line by regiments. The reason of this is, first, that the jealousies of rival commanders of divisions might lead one sometimes to withhold support from another; secondly, that a general's task is much simplified, and he has much better hold of his troops, if his command extends *in depth* rather than *in breadth*.'

Two kinds of tactical advantage have been here discussed: the occupation of favourable ground such as will obstruct the enemy only; and the combination and arrangement of the different arms so as to gain the best effect. But it was also pointed out that the turning a flank or breaking a line may lead to victory by producing new relations between the hostile lines. To obtain such a victory, however, the first successful attacks must be followed up at once. The advanced portion of the assailant's army must be strengthened, the remainder withdrawn out of reach. Dispositions for this must be made beforehand, and hence arise *orders of battle*, or certain relations existing between the hostile lines before or during the encounter. The end and aim of the order of battle is to produce such relations between the hostile lines as ultimately to bring a sufficient part of one *in battle array* across the extremity of part of the other.

An army may attack its enemy in front or flank. If on a flank, say the right, it must retire its own right flank, and so it will be in *oblique order* at the moment of attack; and the examples of the Prussians' defeat at Kolin, and that of Soult at Pampeluna, show the necessity of keeping the retired wing out of the way for a certain time, and prove that it is dangerous to turn an adversary with one wing, unless you refuse or protect the other. But the refused wing must not be kept altogether out of action. It must be engaged either when the progressive advance of the line brings it into contact with the enemy, or if the enemy changes front, by attacking the flank of his new line.

Modern armies no longer, like Frederick's army, adhere absolutely to the oblique form, but adopt its spirit, reinforcing the head of the attack from the reserves, or second line of the refused wing, and masking the front with skirmishers and artillery, under cover of which the troops of the attacking wing are brought into the best position. Battalion columns in échelon, well reinforced at the head, protected on the outward flank by cavalry, with the batteries assembled on the inner, would be a suitable formation for a flank attack. Above all things, the *continuity* of the whole line must be preserved during the attack.

But the commander of an army against which such a movement is directed may strike in return at the attacking wing, in which case, if successful, he will drive back the enemy along the line by which he advanced; or he may deal his counter-stroke at the refused wing, as Napoleon did at Austerlitz, in which case success will be far more decisive, for having beaten the refused wing, he may turn, and envelope and destroy the other. This will be the best course, unless distance or position should render it impossible.

The attack of a wing, or of a centre and wing, or the order écheloned on a wing, are all varieties of the oblique order.

The danger of the formation in a *salient angle* for defence has been already shown; but there are cases where (as at Gettysburg, where the Federal forces, so drawn up, had at the angle a hill protecting the lines from enfilade) the formation may be safe. But attacks almost of necessity assume this order, for on the centre of a line the continuity of the attacking force must be preserved. Such attacks, however, being unforeseen, are not met by a corresponding enclosing angle on the part of the defender, which is the only effectual counter-order. An attack of this kind, with cavalry at the apex, is

especially suitable when the enemy, by undue extension, has weakened part of his front.

Another *angular order* is the *re-entering* or *enclosing angle*, such as was formed by the Allies at Waterloo after the Prussian advance. But no enemy will wilfully enter into an enclosing angle; and if it were formed before his entry, it would but expose both flanks to his attack.

The *convex order* is merely another variety of the salient angle, and is a term loosely used to signify an army écheloned on the centre, or in some other angular form. Similarly, the *concave order* is but a form of the enclosing angle. Thus all *orders* may be reduced to *oblique* or *angular*.

In preparing for the attack, a commander's first object must be to disguise its nature from his enemy; and this he will do by concentrating his troops, covered by the fire of artillery, along the whole line. He must also bring masses of artillery to bear on the part which he means to attack, so as to weaken it before the advance of his troops; these will be preceded by swarms of skirmishers, who may also conceal the retirement of any part of his line.

In all cases, before deciding on the order of battle, the point of attack must be fixed upon. This the general must choose according to circumstances, selecting that point where his attack, if successful, will do the greatest injury, such as the flank resting on the base, the connecting point of two allied armies, the wing which is traversed by the line of retreat, or, of course, the weakest point of the enemy's line, bearing in mind that the mere forcing an enemy off the field without turning his flank, or breaking his centre, is an indecisive victory. Advanced posts must be captured: strong points in the line must be avoided, unless upon commanding ground, or where they can be cut off from the remainder. If one flank of the enemy is supported by an impassable obstacle, it will be well to drive the enemy back on that obstacle, so as to destroy him.

If an army be cut from its base, it is at least free from all necessity of choosing any particular lines, and may manœuvre freely to a flank. If a retreat becomes inevitable, it should be disguised by partial attacks, and carried out by the alternate retirement of troops. If an army quits a lost field with the intention of renewing the contest at the first opportunity, it should retreat in the most concentrated form possible; but if it is routed and seeks the shelter of its own frontier, the more roads it can move by the better. The pursuing force should try to strike, not the rear, but the flank of the flying army.

To sum up in Colonel Hamley's words: 'The assailant's order of battle must depend on the points selected for attack, and the selection of these points must depend on circumstances already discussed. A general, taking up a defensive line, or attacked while manœuvring, should seek to obtain as far as possible the following conditions:—

'1. By the direction of his front, to cover his line of retreat as squarely as possible, without lending a flank to the enemy.

'2. To occupy ground which cannot be approached within range unawares.

'3. To insure free communication between parts of his front.

'4. To conceal his movements and force as much as possible.

'5. To seize such advanced posts as will strengthen his front.

'Lastly, he must take up his ground with a view to the action of that arm in which he may be proportionately strongest or superior to the enemy.

'Viewing the case from the other side, the assailant must first choose his points of attack. In order to do this confidently, he must fully understand his adversary's dispositions, by reconnoitring, if possible, the whole extent of his line. . . .

'This done, the assailant must make his dispositions, (1) for disguising his attack, (2) for executing it, (3) for supporting it, and (4) for refusing the containing or defensive parts of his order of battle.'

The introduction of arms of precision has modified previously existing conditions, but does not seem to have produced any radical changes. The fire of infantry has extended its *effective* range from less than 200 to 600 or 700 yards, and has gained in volume and rapidity by the introduction of breech-loading arms. The effective fire of field artillery is extended from 1,200 or 1,400 yards to 2,000 or 2,500 yards. This would at first seem to imply that to advance against such a fire must be almost impracticable, but it is not so. Many reasons lessen the efficacy of these arms, most especially the conformation of ground, the smoke of artillery and musketry, the dust or fog, and the excitement and stress, moral and physical, of sustained conflict. All these greatly diminish the effect of weapons requiring a clear range and deliberate adjustment. Still the advantages of defence are doubtless increased by them to the army which in a sheltered position awaits the attack. The line of battle must be formed farther off, and the attacking troops must be longer exposed to fire.

An advance in line would, if it were possible, insure the least loss to the assailant, but such a thing is never practicable for a large force on average ground. Deep columns would be fatal, and must be absolutely condemned, so that apparently columns of small depth must be the formation for future attacks: but these must be covered by skirmishers in great numbers. Every possible shelter will have to be seized by the advancing troops; and their advance must be preceded by a concentrated fire of artillery. *Rapidity of movement must be made to counteract rapidity of the enemy's fire.* A lighter and quicker system of drill must be adopted, though the general principles in action will remain unaltered.

The same remark applies to artillery. Bat-

teries must all be made to move with rapidity, so as to be able to take action according to the enemy's rapid movements, and must be massed, as heretofore, for the decisive stroke in battle.

The value of cavalry under present conditions is more doubtful. Whether it will be able to hold its position as an agent in the shock of battle, is a question even as yet scarcely solved. It is argued that it will be destroyed by the projectiles of the enemy before it can reach the point of action. But here again increased rapidity, gained by increased lightness of equipments, must be acquired. Once closed with the adverse line, it has no more to fear than formerly. Its drill, too, must be simplified to admit of much faster manœuvring, and artillery must, as before, be associated with it in order to protect it. Whether it will ever avail against well-formed troops, must be decided by experience not even yet gained. That it will be as valuable as ever for covering a retreat, was clearly proved by the experience of the Austrian retreat after Königgratz; and 'launched in pursuit of a broken foe, it may finish a campaign which would else wade through fresh carnage to its woeful end.' But its highest application must depend on the genius of its commander.

As regards the influence of modern arms on manœuvres, it is probable that turning movements will be greatly employed to save the loss which must be suffered in direct attacks. But when an attack is judged practicable, the severity of the fire will probably always cause the two opposing parties to have recourse in a very short time to the use of the bayonet, and the army acting on the defensive will probably make great use of fieldworks.

The limits allowed in this article forbid our entering on the questions of the dispositions for the march that precedes a battle, and the many minor operations of war, such as advanced guards, outposts, convoys, reconnaissance, &c.; although these are of vital importance in the successful conduct of a campaign.

'In passing from the consideration of tactics, and the changes that art is undergoing, it seems necessary to refute but one more popular error, which has been countenanced by names lent to it with perhaps injudicious haste. It has been said that the rapid multiplying of railways and their dépôts must tend to modify the condition under which troops are brought into action. In so far as this relates to their actual collision, this is plainly an error. Cuttings, embankments, crossings, bridges, are none of them new creations. The defence of a railroad station is that merely of a building of certain size, and involves no new principles. Had the increasing wealth of civilised countries not spent itself in this way, it would have found, as it still finds, other outlets in forms of planting, building, draining, which would change particular fields of combat, but in no way affect a certain system already adapted for seizing or maintaining a given position, or show that it could be, as a whole, altered for the better. The idea, baseless when viewed in this light, has been supported by the alleged winning of the battle of Montebello by the French as a consequence of their actual use of a railway to bring up reinforcements; and the employment of trains during a single action has been mixed up with the general notion of the value of railroads for battle purposes. Space does not allow us to follow out the details of the affair where Forey won his reputation. It is enough to say that Rüstow (an able writer, and, as between Emperor and Kaiser, thoroughly impartial) denies in his work this pretended cause of the defeat of the Austrians, and ascribes it simply to the well-known want of resource and self-possession which has, for the last eighty years, constantly marked their general officers when detached. It may be added that the long annals of the American war give no reason to believe that we are near the day when commanders will arrange their order of battle with a view to bring their troops under fire by train.

'Far otherwise is it as regards the greater combinations of war. The wondrous facilities which steam conveyance and the electric telegraph afford for transporting and collecting troops and supplies seems to promise almost as great a revolution in strategy as gunpowder is admitted to have made in tactics. . . .

'The least observation of these phases of that gigantic contest (the American war), added to what we have lately seen in Italy and Denmark, is sufficient to show a great change to come in future European wars. Old lines of defence must vanish, bases formerly distant be brought near, concentration of great masses be the rule rather than the exception, months of preparation and of movement be contracted into days. As regards the strategy of purely inland campaigns, railroads and telegraphs, it may be freely assumed, will soon be so multiplied that their effect will be felt in this way wherever civilisation extends. This will be generally admitted. But it is not so apparent at first that a similar change may be expected wherever the theatre of war is open to approach by navigation. In spite of Crimean experience, and of the marvels worked by Grant when he had once felt his way to the true use of his steam transports, few are aware how immensely the naval powers of the world have augmented the striking force of their armies by the improvements in their fleets. France has been long the most formidable of neighbours; but it is not too much to say that her present policy of amity with England, and the undisputed rank of her navy as the second in Europe, has doubled at the very least her warlike means against all the other Continental powers.' (*Edin. Rev.* Jan. 1866, 'Recent Changes in the Art of War.')

In this brief sketch of the operations of modern warfare, we have followed closely the order of subjects, and the manner of treatment, adopted in Colonel Hamley's invaluable work, *The Operations of War explained and illus-*

trated (London and Edinburgh 1866), which, as it is the latest, is also the best work in the English language for the student of the art of war. The reader who wishes to pursue the subject further, may find study for a lifetime in the works of Clausewitz, the Archduke Charles, Jomini, Marmont, Baron Ambert, and Napier, the *Napoleon Correspondence*, the *Wellington Despatches*, and other works, to which these will lead him. We would conclude with another sentence of Colonel Hamley's: 'The moral is, not that numbers and wealth must prevail, nor that great generals are heaven-born: it is, on the contrary, that the conditions of success are attainable and capable of demonstration; that the preparation of study and thought is essential to skill in war; and that, being thus prepared, a leader, in order to achieve the most notable successes, need not be gifted with inspiration, but only with the more appreciable, though still rare, combination of sound sense, clear insight, and resolution.'

War, Private. According to the ancient Greek theory, as well as to those of barbarous nations generally, men are in a state of natural enmity, and friendship is distinctly a matter of special contract. Hence, apart from this contract, there is on this hypothesis a right inherent in every man to avenge his wrongs against his neighbour if he is able to do so. If the city or state to which he belongs can do this for him, so much the better; if not, he reverts to his own inalienable privilege. To this plea the feudal nobility of the middle ages had recourse without scruple, when legal compositions, as of WERBGILD, proved insufficient, or other causes of quarrel occurred. Against these feuds (faida) or private wars, many of the capitularies of Charlemagne are directed; but, after his time, the practice continued almost without let or hindrance. In the absence of judicial tribunals able to enforce their awards, Mr. Hallam thinks that the higher nobility of France in that age may be regarded as in a state of nature with respect to each other, and entitled to avail themselves of all legitimate grounds of hostility. (*Middle Ages*, ch. ii. part ii. § 2.)

Ward. In Feudal Law, the heir of the king's tenant in capite during his nonage was so called; and, in general language, all infants under the power of guardians. [GUARDIAN.] The court of *wards and liveries*, for cognisance of various matters relating to the king's prerogative, was established by Henry VIII., and abolished at the Restoration. (*Archæologia*, vol. ii.)

Ward's Paste. A quack medicine, of which *pepper* is the active ingredient, and which has obtained some celebrity as a remedy for piles, and for fistulæ and abscesses about the rectum.

Ward-room. In large ships of war, the cabin set apart for the abode of officers ranking as lieutenants. Small ships have no ward-room.

Warden, Lord, of the Cinque Ports. [CINQUE PORTS.] The constable of Dover Castle was created warden of the Cinque Ports and guardian of the adjacent coast, by William the Conqueror: an office resembling that of the comes littoris Saxonici in the decline of the Roman empire. The lord warden had a peculiar maritime jurisdiction. His jurisdiction in civil suits has been recently abolished (18 & 19 Vict. c. 48). The office is now little more than a sinecure, and valuable chiefly as giving a right to the use of Walmer Castle as a residence.

There is also a lord warden of the STANNARIES.

Wardmote. A court in each ward of the city of London, which has power to present defaults in matters relating to the watch, police, &c.

Warehouse, Bonded. A building in which duty-paying and excisable articles can be stored during the period which intervenes between their importation or production and their consumption. The charge paid for storing such articles is as low as possible; and, as a rule, if they are re-exported, or if, being produced at home, they are consigned to foreign countries, no duty at all is paid. The object of such an arrangement is that the tax levied indirectly on consumption may be as light as possible, because the period between the payment of the tax and the consumption of the commodity is as short as possible.

The manifest advantages which the general public obtain by the adoption of a warehousing system, was early recognised when the pressure of public debt and increased domestic expenditure aroused the attention of financiers. Hence Sir Robert Walpole attempted, in 1733, to establish such warehouses in the principal British ports. But the leading London merchants, to their infinite disgrace, stirred up the public, by a variety of ridiculous fallacies, to resist the system; and the odium excited was so great, that Walpole was obliged to abandon his project. The weak point in Walpole's scheme was the double arrangement of levying excise and customs duties on imports. If by means of a bonded warehouse the duty could be levied as nearly as possible at the time of consumption, there could be no reason for retaining an excise on such articles. The opposition to the arrangement, however, was so strong, that for seventy years this obvious and useful system was postponed. Now, however, it is applied to every kind of article produced abroad or at home, on which any duty is charged, with one exception, corn, the duty on which, 1*s*. the quarter, or 3*d*. the cwt., is a landing not a bonding duty.

The advantages of the warehousing system are greatly increased by the facilities of transport which are accorded by railways: at present, the trader in duty-paying articles keeps the least possible stock in his possession; for, in consequence of the ease with which he can obtain a fresh supply, he economises that portion of his capital which is invested in the payment of duties as fully as he can.

Waring's Method. The object of this method is to separate the roots of an algebraic equation; it requires the formation of the equation whose roots are the squared differences of the roots of the original. [EQUATION OF SQUARED DIFFERENCES.] If k^2 denote an inferior limit of the roots of the latter, a and b being respectively the superior and inferior limits of the roots of the original equation $F(x)=0$ (all which limits can be easily determined); then, from the signs of $F(a)$, $F(a-k)$, $F(a-2k)$. . . $F(b)$, the positions of all the real roots of the given equation may be at once ascertained; for, between any two adjacent values $a-mk$ and $a-(m+1)k$, not more than one root can be situated, and its absence or presence will be indicated by the like, or opposite, characters of the signs of $F(a-mk)$ and $F(a-\overline{m+1}k)$.

Waring, who was Lucasian Professor of Mathematics at Cambridge about the year 1760, published several papers on equations in the *Phil. Trans.*, as well as a separate treatise entitled *Meditationes Algebraicæ*, at Cambridge, in 1770.

Warming and Ventilation. [VENTILATION.]

Warmth (a Teutonic word, akin to Sansc. gharma, Gr. θερμός). In Painting, a tone of colour arising from the use of colours expressive of heat, or the so-called hotter colours, as reds, deep yellows, russet browns, &c.

Warp. In Naval Affairs, *warp* signifies a rope laid out for the purpose of moving the ship. *To warp* is to move a ship from one position to another by means of warps.

WARP. In Weaving, the *longitudinal* threads of a woven fabric; they are crossed by the *transverse* threads, or *woof*.

Warping (Fr. guerpier). A mode of increasing the fertility of tillage lands on the banks of rivers liable to be overflowed by them. It appears to have been first practised in Britain on the banks of the Trent, Ouse, and other rivers which empty themselves into the estuary of the Humber. The waters of these rivers, from passing through a great extent of alluvial country, are, after heavy rains, exceedingly muddy; and they are in that state conducted over the adjoining surface in portions enclosed by banks, and there suffered to deposit their mud, which is technically called *warp*, and which being of the depth of an inch or two, adds greatly to the fertility of the soil, and indirectly on consumption may be as light as existed on the banks of the Po, and other rivers in the north of Italy, from time immemorial.

WARPING. In Architecture. [CASTING.]

Warrant (Welsh gwarant). In Law, a precept under hand and seal, directed to a proper officer, to arrest an offender.

Warrant of Attorney. In Law, a power given by a client to his attorney to appear and plead for him, or to suffer judgment to pass against him by confession. It authorises a creditor to enter up judgment and levy execution, and is frequently granted as a security for a debt.

Warrant Officers. In the Navy, the gunner, boatswain, and carpenter.

Warranty. In Law, as applied to lands, a promise or covenant real annexed to lands or hereditaments, whereby the conveying party was bound to warrant the title of the same, against all men. But the ancient law of warranty of real property, after having been long obsolete in practice, was superseded by the stat. 3 & 4 Wm. IV. cc. 27, 74. It is, however, still the practice to insert in conveyances *covenants for the title* to the land conveyed, which to some extent answer the purpose of the old warranties.

With regard to warranty of things personal, it is the general rule that a purchaser of goods and chattels may have a satisfaction from the seller, if he sells them as his own and the title proves deficient, without any express warranty for that purpose; but that with regard to the goodness of the things so purchased, the vendor is not bound to answer, unless he has expressly warranted them to be good, or unless he has in any way misrepresented them; but a warranty is implied in certain cases by the custom of trade or the nature of the contract. [TITLE.]

Warren (Fr. garenne, from the Teutonic wahren, *to protect or defend*). In Law, a franchise or place privileged for the taking or keeping of beasts and fowls of warren, which are said by some to be only hares and rabbits, partridges and pheasants; others add quails, woodcocks, waterfowl, &c. The franchise is from the crown by grant, or prescription which implies grant. It is often called *free warren*, and in some cases denotes the right of sporting over the land of another; for by the common law the right of taking or destroying game belonged exclusively to the king or to those to whom he had granted it, and it not unfrequently happens that under ancient grants the right of warren, i. e. of taking and destroying game, has become vested in persons not the owners of the soil. [GAME LAWS.]

Warwickite. Native borotitanate of magnesia and iron, met with in dark-brown to black crystals, in granular limestone, near Edenville, New York, U.S.

Washboard. In Sea language, a movable piece of board placed above the gunwale of a boat, or elsewhere, to prevent the water from washing over.

Washer. A circular piece of leather, or pasteboard, placed at the base of a screw, so as to prevent the metal surfaces from being injured when it is screwed home; it is also used to render screw and other junctions air-tight.

Washingtonite. A kind of titaniferous iron-ore of a steel-grey colour, met with in Connecticut, and said to occur, also, at Breaghy Head, in Donegal, and at Ballinascreen, co. Derry. Named after General Washington, president of the United States.

Wasp. [VESPIDÆ.]

Wassail (A.-Sax. waes hael, *be in health*). A common salutation used in drinking: whence the *wassel-bowl*, which was anciently carried

round on New Year's Eve. 'A carol for a wassel bowl' will be found in Ritson's *Ancient Songs*, 1790, p. 304. (Brand, *Popular Antiquities*, vol. i. p. 1.)

Waste (Lat. vastus). In Law, the destruction or material alteration of things forming an essential part of the inheritance; as houses, timber, &c. Neglect of repairs is termed *permissive* waste; active injury, *voluntary* waste. The Court of Chancery will interfere by injunction to restrain the committing of waste by persons having estates for life or other limited interests in land; and even although the estate or interest of the person attempting to commit waste be expressly given to him *without impeachment of waste*—in which case he may cut timber in a husbandlike manner for his own benefit, work mines, and the like—the court will still restrain him from felling ornamental timber, pulling down the family mansion, and similar acts, which are known as *equitable* waste; and a person improperly committing waste or equitable waste may be made to account for any money produced thereby at the instance of those entitled in remainder.

Waste Land. Any tract of surface not in a state of cultivation, and producing little or no useful herbage, or wood. It was estimated by Sir John Sinclair, about the end of the last century, that the quantity of waste land in Great Britain amounted to 22,107,001 acres (England and Wales 7,888,777, Scotland 14,218,224), 3,000,000 of which he considered capable of being brought under the plough, and the greater part of the remainder of growing wood. Large quantities of this common and waste land have been enclosed during the present century, and the amount of waste land in England has been so much reduced, that some alarm has been lately felt, lest the progress of enclosures should deprive the inhabitants of large towns of their accustomed opportunities of exercise and recreation. Steps have been taken in many cases to preserve for public use commons situated in populous districts, and an Act of Parliament was passed in 1866 to make provision for the improvement, protection, and management of commons near the metropolis.

Watch (A.-Sax. wacian, Ger. wachen, *to wake*). This word is frequently used to denote the portions into which the night was divided for the duties of sentinels. Thus the Romans had four watches, and the Jews three.

WATCH. A well-known portable machine, moved by a spring, for measuring time. When executed in the most perfect manner, it is called a *chronometer*, and used in navigation for determining differences of longitude. [CHRONOMETER; LONGITUDE.]

Watches are said to have been made at Nuremburg so early as 1477; but it is uncertain how far the watches then constructed resembled those which now go by that name. Some of the early ones were very small, in the shape of a pear, and sometimes sunk or fitted into the top of a walking-stick. As time-keepers watches could have very little value before the application of the spiral spring as a regulator to the balance. The merit of this excellent invention has been claimed by Hooke and Huygens; but it seems established by unquestionable evidence, that the priority belonged to Hooke by at least fifteen years. The date of the invention is about the year 1658. Hooke's first balance spring was straight, and acted on the balance in a very imperfect manner; but he soon perceived its defects, and attempted to obviate them by adopting first the cylindrical, and afterwards the flat spiral. The latter appears to have been applied to watches before the publication of Huygens' claim in 1675. [HOROLOGY.]

WATCH. On Shipboard, the portion of the ship's crew on duty at a time. This is usually half; and the watches are called the *starboard* and *port* watches. Large crews are put in three watches. The period of the time called a watch is four hours, the reckoning beginning at noon or midnight. Between four o'clock and eight P.M. the time is divided into two short or *dog* watches, in order to break the constant recurrence of the watches at the same hours.

Water (Ger. wasser). The old chemists considered water as an element, and supposed it convertible into earth, and into various organic products. This opinion was first questioned, and afterwards disproved by the experiments of Watt and of Cavendish, in the years 1786 and 1787. (*Phil. Trans.*) It has since been satisfactorily demonstrated that hydrogen and oxygen are the elements of water, and that they are contained in it in the relative proportions by weight of 1 and 8, or by volume 2 and 1; the specific gravity of hydrogen being to that of oxygen as 1 to 16; 3 volumes of the mixed gases producing 2 volumes of steam, the specific gravity of which referred to hydrogen as unity is 9.

The electro-chemical decomposition of water is that which affords the most satisfactory evidence of its nature. When made part of the volta-electric circuit, it is resolved into 2 measures of hydrogen and 1 of oxygen gas, the former evolved at the negative, and the latter at the positive surface; and if the gases thus obtained be mixed, and fired by the electric spark, they again combine, and produce their weight of water. The analytic and synthetic evidence, therefore, of the composition of water is thus rendered complete.

But although perfectly pure water, such, for instance, as has been boiled and very cautiously distilled, is in fact an *oxide of hydrogen*, and composed as above stated, all natural water is more or less contaminated by foreign matters, which if not in excess, or of an uncommon or injurious nature, render it sometimes more fit for the ordinary uses to which it is applied.

The impurities present in natural water may be divided into four classes: 1. Mechanical impurities; 2. Gaseous impurities; 3. Dissolved mineral impurities; and 4. Organic impurities.

Rain water collected at a distance from inhabited places and upon insoluble surfaces of rock or sand is the purest kind of natural water. It is, however, charged with the gases of the atmosphere with which it comes in contact during its descent to the earth, viz. oxygen, nitrogen, and carbonic acid gas. The rain which falls during and after thunder storms is often found to contain very appreciable quantities of nitrate of ammonia, produced by electric discharges through moist air.

The variety of natural water which is next in purity to rain water is that of some rivers and lakes in mountainous and rocky districts, where the soil contains merely traces of soluble matters which are washed down by the abundant rain of such localities. These waters, of course, contain the same impurities as rain water, together with small quantities of mineral salts, and generally of organic matter. Then follow in purity the waters of springs and rivers, which contain very varying quantities of mineral compounds, depending, of course, on the quality of the strata through which they have passed. Lastly, the waters of the sea and of certain inland lakes contain very large quantities of mineral matters, brought down by rivers which are charged with the soluble matters of the earth's surface.

All these varieties of natural waters may be purified by carefully distilling and rejecting the first and last portions which pass over, the former containing a portion of the gases, and the latter being liable to contamination with the saline bodies originally dissolved in the water.

The four classes of impurities mentioned above differ very much in their importance with regard to the use of the water for various purposes; a glance at these may be interesting.

Mechanical Impurities.—These may be both mineral and organic. The mineral mechanical or suspended impurities are contracted by the water during its passage through the earth or over its surface, and consist principally of sand, clayey matter, chalk, and other insoluble compounds. The organic suspended impurities consist of animal and vegetable organisms, either living or dead, of animal remains and refuse, and of vegetable matter. All these impurities may be separated almost entirely by allowing the water to settle, and then pouring off the clear liquid, or more perfectly by filtration through some porous material, as unglazed paper, sponge, sand, &c.

These impurities communicate an unpleasant turbid appearance to the water, although on account of their ready removal they are not, in themselves, much to be feared; the decomposition of the animal and vegetable matters may, however, give rise to the production of compounds not only noxious, but dangerous to animal life.

Solid constituents in 100,000 *parts of various Waters supplied to Towns.*

	London				Farnham	Watford	Aberdeen	Liverpool
	New River Company	East London Company	Kent Water Company	Thames Ditton and Grand Junction Company				
Carbonate of lime	11·17	14·51	10·03	16·84	0·33	23·04	1·21	1·08
Sulphate of lime	4·61	3·33	15·76	4·37	1·87	—	0·17	1·43
Nitrate of lime	0·03	1·03	0·10	0·39	Trace	0·33	—	—
Carbonate of magnesia	1·56	2·16	4·88	1·81	0·91	1·07	—	0·16
Sulphate of magnesia	—	—	—	—	—	—	0·46	—
Chloride of sodium	2·47	2·51	5·00	1·57	1·33	1·44	0·96	2·23
Sulphate of soda	2·13	1·34	—	—	0·10	1·87	—	—
Chloride of potassium	—	—	—	0·96	—	—	—	—
Sulphate of potash	1·58	1·79	1·00	0·24	0·61	0·63	—	—
Iron, alumina and phosphates	Traces	0·67	Traces	0·13	1·26	—	0·11	0·34
Silica	0·71	0·89	1·08	0·89	1·41	2·27	0·20	0·21
Organic and other volatile matter	0·98	1·62	1·65	1·54	2·54*	1·80*	2·60*	2·00*
	25·24	29·85	39·50	28·74	10·36	32·45	5·71	7·45

* In all probability these numbers are too high, as the method formerly employed for the estimation of organic matters in waters gave results considerably in excess of the actual amount present.

Gaseous Impurities.—The nature of the gaseous bodies present in natural waters varies according to the localities from which they are obtained. Rain water, which has fallen at some distance from large towns, contains little more than oxygen, nitrogen, and carbonic acid gas, but that which is collected in the neighbourhood of cities, or in manufacturing districts, is liable to contamination from some of the waste products of furnaces. Waters of springs and rivers also frequently contain large quantities of gases. Some waters which have percolated

through the chalk formations appear quite milky when first drawn, owing to the minute bubbles of carbonic acid gas escaping from the liquid. Some waters, as those of Harrogate and Aix-la-Chapelle, contain notable quantities of sulphuretted hydrogen gas. Most natural waters contain a considerable quantity of oxygen, unless, from extreme pollution of the water by organic matters, the whole of the oxygen has been absorbed by these bodies.

With the exception of sulphuretted hydrogen, these gases are not deleterious; in fact, without them, neither animal nor vegetable life could be sustained in the waters, and they appear also to communicate an agreeable taste to the liquid. It was proposed many years ago to supply ships with sea water purified from its salts by distillation, but thus obtained it was found so unpalatable as a beverage that it could not be used until a means was devised for aërating it, and thus removing its unpleasant *flat* taste. The ships of the royal navy are now provided with distillatory and aërating apparatus, which render them independent of water supply from land sources.

Dissolved Mineral or Saline Impurities.—These are of the most varied description, and are contracted by the waters of springs and rivers during their passage through and over the surface of the earth. They severally constitute by far the larger proportion of the substances present in waters: their quantities and varieties will be seen from the following table, which contains the analyses of the water supplies of some towns.

Water of Loch Katrine supplied to the principal part of Glasgow.

Peroxide of iron	0·343
Lime	0·731
Magnesia	0·219
Potash	0·043
Soda	0·320
Chloride of sodium	0·017
Sulphuric acid	0·660
Phosphoric acid	trace
Carbonic acid	0·562
Silicic acid	0·176
Organic and other volatile matter	0·071
	3·142

The waters of the New River and East London companies are obtained from the river Lea; the latter company's works, however, are much farther from the source of the river than those of the former; and the different composition of the water, particularly the much larger proportion of the organic matter in that of the East London company, shows conclusively the contamination which it has undergone (from sewage and other matters) in its course towards the Thames. In other respects these waters have very similar compositions, except that in the East London the quantities of carbonate and nitrate of lime are rather higher than in that of the New River. The Kent water company draws its supply from Artesian wells, and very different results are obtained by the analysis of this water. The total amount of solid residue is very much greater than in the other two cases; and although the quantity of carbonate of lime is less than in the New River water, yet the amounts of sulphate of lime, chloride of sodium, and carbonate of magnesia, are very much increased. The Grand Junction water may be taken as a sample of the water supplied to the west and southern districts of London, and which is all taken from above Teddington lock, and therefore above the influence of the tides. In this case the total solid residue stands intermediate between that of the New River and East London water; the organic and other volatile matter is also less in quantity than in the cases of the East London and Kent companies; but the principal difference between the Grand Junction and the other waters consists in the very large quantity of carbonate of lime contained in it. The water from Farnham, which is next on the list, and with which it was once proposed to supply London, is obtained from springs from the greensand, and is far purer than the waters already mentioned. The amount of total solid residue is about one-third of that of the river waters, and one-fourth of that of the Kent company's. The water from Watford contains a very large amount of solid compounds, the chief part of which consists of carbonate of lime: the organic and other volatile matter in this case is slightly more than in the previous instances. The waters supplied to Aberdeen and Liverpool follow in the table, and stand in great contrast with the London waters, although they are inferior to the Loch Katrine water, which is remarkable for its great purity. The latter contains a quantity of solid residue about one-tenth of that of Thames water, and far less organic and other volatile matter than any on the list.

The most objectionable of the saline impurities are the salts of magnesia and lime, as they communicate to the water a *hardness* which is due to the property possessed by these compounds of decomposing soap. Soap consists principally of an alkaline salt of stearic acid, and is perfectly soluble in pure water, producing, when the solution is agitated, a froth termed *lather*, which must be formed before the detergent properties of the soap can come into action. When soap is introduced into water containing salts of lime or magnesia, double decomposition takes place, an insoluble stearate of lime or magnesia being formed which constitutes the greasy curds which are seen in all hard waters when soap has been introduced into them. The detergent action of the soap cannot, therefore, come into play until a sufficient quantity has been employed to remove the lime and magnesia from the water; when this is accomplished, a lather is formed and the soap becomes available. Besides this, the stearate of lime is precipitated in the pores of

the skin, and may even cause their stoppage, a result which must be detrimental to the healthy action of the skin. The salts of potassium and sodium present in the waters have no deleterious action on soap, and on this account the Loch Katrine water is very suitable for washing purposes, one-third of the solid residue consisting of sodium salts, a little more than one-third of organic matter, and less than one-third of calcium and magnesium compounds.

The following extract from Dr. Frankland's Report to the Registrar-General for the year 1866 will give a good indication of the composition of the water supplied to the metropolis.

Companies	Solid Matter in 100,000 parts of Water	Organic and other Volatile Matter in 100,000 parts of Water	Amount of Oxygen required for Oxidation of Organic Matter	Hardness
Water of Companies drawing from Thames	27·88	1·29	·0571	19·5
Kent Company (Artesian Well)	39·03	1·34	·0096	26·5
South Essex Company (Artesian Well) . .	38·77	1·55	·0138	25·1
New River (River Lea)	24·85	1·05	·0268	18·4
East London (do.) . .	30·48	1·42	·0474	20·4

In these analyses the results are obtained in the following manner. The amount of solid residue is determined by evaporating in a platinum dish, of known weight, a litre (or 1,000 cubic centimètres) of the water, which has been previously mixed with a quantity of a standard solution of carbonate of soda containing exactly 0·1 grm. of the carbonate. When the evaporation is complete, the dish is placed in an oil bath and heated to a temperature between 120° C. and 130° C. (248° to 266° Fahr.), and allowed to cool in dry air and rapidly weighed. This weight, *minus* the weight of the dish, and the 0·1 grm. of carbonate of soda added, gives the weight of the solid residue.

The organic and other volatile matter is estimated by carefully igniting the residue in the dish and maintaining it at a dull red heat until the organic matter is burnt off. When cool, a saturated aqueous solution of carbonic acid gas is added to the residue, in the quantity of about 20 cubic centimètres to every 0·1 grm. of carbonate of lime or magnesia present. The liquid is then evaporated, the residue heated to a temperature between 120° and 130° C., and weighed as before; the loss between the two weighings gives the amount of organic and other volatile matter present in the water.

The amount of oxygen required for the oxidation of the organic matter, is determined by mixing half a litre of the water with 15 cubic centimètres of dilute sulphuric acid (1 vol. of acid to 5 of water), and gradually adding a standard solution of permanganate of potash, until a pink colour, permanent for 10 minutes, is obtained; this observation being made through a stratum of the liquid about 12 inches in depth.

It is frequently thought that the amount of permanganate required in order to obtain this result is a certain measure of the amount of organic matter present in the water. This, however, is an error, as some organic substances, and especially living organisms, resist the action of permanganic acid to an extraordinary extent. The amount of oxygen required is supposed to indicate the more dangerous varieties of organic matter, and those from which it is advisable that the water should be as free as possible.

The hardness is determined by the soap test (proposed many years ago by Dr. Clark), which consists in adding a standard solution of soap in dilute alcohol, until on agitation a lather is produced which remains permanent for 5 minutes. The degrees of hardness first proposed by Dr. Clark, indicated the number of grains of carbonate of lime, or its equivalent, contained in one gallon of water: in the above table, the hardness is given in units of carbonate of lime in 100,000 parts of water. The total hardness is determined in the water in its original state, and the permanent hardness after boiling for half an hour; the temporary hardness is found by difference.

The carbonate of lime present in natural waters, is held in solution by an excess of carbonic acid in the form of an acid carbonate: on boiling, this compound is decomposed, carbonic acid gas being evolved, and the carbonate of lime precipitated: this carbonate constitutes the incrustation formed on the interior surfaces of boilers and other vessels, in which hard water is heated, and frequently gives rise to very great inconveniences. Boiler explosions are sometimes attributed to this deposit. Various methods have been suggested to prevent its formation: one is to introduce some sal-ammoniac into the boiler; this, by double decomposition with the carbonate of lime, produces carbonate of ammonia, which volatilises with the steam, and the very soluble chloride of calcium, which remains in the liquid condition until the water is evaporated to dryness, which of course never takes place in a boiler. Another method which prevents the precipitation of this compound on the surface of the boiler, is to introduce a quantity of potatoes. These are disintegrated, and the carbonate of lime appears to be deposited on the fibre of the vegetable, forming a flocculent matter, which remains suspended in the water, and does not adhere to the vessel.

A very elegant method of removing the carbonate of lime from water to be used for domestic purposes, has been suggested by Dr. Clark. It consists in adding a quantity of lime water or milk of lime, which, uniting with the excess of carbonic acid present, precipitates it in an insoluble condition, and removing at the same time the substance which holds the carbonate of lime in solution in the water, precipitates that quantity also:—

$$\underbrace{CaO, CO_2, HO, CO_2}_{\text{Acid carbonate of lime.}} + \underbrace{CaO, HO}_{\text{Lime.}} = \underbrace{2\,(CaO, CO_2)}_{\text{Carbonate of lime.}} + \underbrace{2\,HO}_{\text{Water.}}$$

This produces the same result as is obtained by boiling; and at one time the water supplied by some of the water companies was softened in this manner. It was found, however, to be inconvenient and expensive when applied on a large scale. It has also the disadvantage that it removes only the carbonates of lime and magnesia, leaving the earthy sulphates and chlorides, which are quite as objectionable, untouched. The following process may be usefully employed for domestic purposes. It consists in the introduction into the water of a small quantity of carbonate of soda (ordinary washing soda), which precipitates all the salts of lime and magnesia, entirely softening the water. Unfortunately, the cost of carbonate of soda prevents the application of this process on a large scale. It is necessary in this case, as well as in the lime process, to avoid adding an excess of the softening agent. In the case of lime, an excess is liable to increase the hardness which it has previously reduced; and although this does not hold good with the carbonate of soda process, yet too large a quantity of this salt produces a harshness on the skin, when the water is employed for washing purposes.

Some natural spring waters contain an abnormal quantity of mineral salts, or sometimes salts of a peculiar character; they are then called *mineral waters*. Thus some springs contain sulphate of magnesia, as the Epsom waters; and others sulphate or carbonate of iron; these are called *chalybeate* springs.

The waters of the sea and of some inland lakes which have no outlet, contain abnormal quantities of mineral constituents.

The Dead Sea is one of these, and all the water which it receives from the Jordan and other streams evaporates, leaving the saline constituents behind. The water of the Jordan contains 107·14 parts of solid constituents in 100,000 parts, and thus it is not surprising that the Dead Sea contains in the same quantity no less than 24,056 parts. Again, the Elton lake, in Russia, is a saturated solution of chloride of sodium, and during the summer it is covered with a solid crust, of which 200,000 tons are annually extracted from the lake. The water of the Dead Sea is now employed for the manufacture of bromine, of which it contains considerable quantities. The analyses of this water exhibit the most extraordinary discrepancies, due doubtless to the great length of time required for the complete mixture of the waters of the rivers with that of the lake. The following, which is about midway between the highest and lowest analyses, will give a notion of the immense quantity of salts which it contains:—

Solid constituents in 100,000 *parts of the Water of the Dead Sea.*

Chloride of calcium	2,455
Chloride of magnesium	7,822
Chloride of potassium	1,217
Chloride of sodium	12,110
Chloride of aluminium	56
Chloride of ammonium	6
Chloride of manganese	6
Chloride of iron	3
Bromide of magnesium	251
Sulphate of lime	68
Carbonate of lime	trace
Silica	trace
Nitrogenous organic substance	62
Bituminous substance	trace
	24,056

The specific gravity of the water was 1·172.

The composition of the sea is subject to slight variations, according to the circumstances of the place from which the water is obtained. The following table will serve to indicate its composition:—

Solid constituents in 100,000 *parts of Sea Water.*

	British Channel.	Mediterranean.
Chloride of sodium	2605·948	2942·4
Chloride of potassium	76·552	50·5
Chloride of magnesium	366·658	321·9
Bromide of magnesium	2·929	55·6
Sulphate of magnesia	229·578	247·7
Sulphate of lime	140·662	135·7
Carbonate of lime	3·301	11·4
Iodine	traces	—
Ammonia	traces	—
Oxide of iron	—	0·3
	3625·628	3765·5
Specific gravity	1·0274 at 15·5° C.	1·0258 at 21° C.

Organic Impurities.—We have now to consider the fourth and last class of impurities present in water; these are the soluble organic impurities which are present to a certain extent in most waters. The vegetable matters are not usually of a very deleterious character; they frequently communicate a brownish colour and a bitter taste to the water. But it is the animal matters which are most dangerous, and which may be the means of spreading contagious diseases.

The presence of organic matter may be detected in waters by evaporating to dryness and heating the residue, when a brownish mass usually results if organic matter is present. It may also sometimes be detected by its decolorising a solution of permanganate of potash as above described.

Organic matters in water may be destroyed by adding a small quantity of permanganate of potash, and boiling; but a preferable method of removing it is by percolation of the water through coarsely powdered animal charcoal. In this process it appears that the organic matters are oxidised by the surface action of the animal charcoal, which retains this property for a considerable length of time; when the action becomes less rapid, simple ignition restores the charcoal to its energetic condition.

In connection with water supply, there is one important subject which must not be overlooked,

i. e. the powerful action that certain waters exercise on lead. Pure distilled water when brought in contact with lead very rapidly attacks it, the liquid being soon filled with fine crystals of a basic carbonate of lead. Thames water, and most spring and river waters, are quite destitute of this action; and it was long thought that the salts present in the water acted in a protecting manner on the metal. When it was suggested to supply Glasgow with water from Loch Katrine, great objections were raised to the scheme on account of the fact that the water of Loch Katrine powerfully affected lead, and it was thought that a large amount of poisoning would ensue from its use. Notwithstanding the opposition, the project was completed, and no trace of lead is found in the water and as supplied to Glasgow it is quite free from action on the metal. It appears that during its transit from Loch Katrine it absorbs carbonic acid gas from the air; and experiment shows that distilled water, containing in solution a sufficient amount of carbonic acid gas, is quite incapable of exerting any dangerous action on lead. This supply of carbonic acid is always obtained during the passage of water through a long conduit, and therefore no danger on this score would be involved in the supply of London, even with distilled water, if it were brought from Wales or Cumberland. [WATER SUPPLY.]

Water Bailiff. An officer in port towns, whose duties in general relate to the searching of ships: in London he has also the supervision of the fish market, gathering of tolls, &c.

Water Chestnut. One of the names for the fruits of *Trapa natans*, and other species of this genus of *Haloragaceæ*.

Water Clock. [CLEPSYDRA.]

Water Crane. A swivelling pipe employed for filling the feeding tank of a locomotive engine with water. The appearance of this pipe resembles that of a crane for lifting goods, and it is swivelled over the line, so that the mouth of the pipe comes over the tank of the locomotive, and thus, by opening a valve, water runs into the tank from an elevated cistern at the side of the railway. [RAILROADS.]

Water of Crystallisation. Some crystallised salts contain more or less water, which, as it bears a definite proportion to the other components of the salt, may be considered as one of its essential constituents. Crystallised sulphate of lime, for instance, is a compound of 68 of dry sulphate and 18 water, or of one equivalent of anhydrous salt and two equivalents of water; one equivalent of crystallised sulphate of magnesia $=123$ contains 7 of water $=63$; and an equivalent of crystallised sulphate of soda $=162$ contains 10 of water $=90$; the equivalent of water being 9. But it does not necessarily follow that a salt in crystals contains water, there being many crystals which are *anhydrous*, such as nitre, sulphate of potash, &c.

Water Devil. A name given by some micrographers to the larva of a British species of *Hydrophilus*.

Water Drops. Rounded pebbles of clear and limpid colourless Topaz.

Water Gauge. A contrivance for ascertaining the height of the water within a steam boiler. Among the expedients adopted for this purpose, one is a series of cocks, usually three, set one above the other in the front of the boiler: the lowest of these cocks should always let out water, and the highest should let out steam. Another expedient is a glass tube set vertically in the front of the boiler; the top of the tube communicating with the steam, and the bottom with the water within the boiler. The water in the tube consequently stands at the same height as the water within the boiler, and so indicates the level. Both of these contrivances are applied to most modern boilers. Another expedient sometimes used is a cock, capable of swilling round its axis in the front of the boiler, so as to bring a piece of pipe attached to its inner end, into the water, when the cock will blow water; the amount of swivelling required for this purpose indicates the position of the water level. In some boilers the height of the water is indicated by a buoy or float, placed on the surface of the water, and communicating with an index outside.

Water Meadows. Meadows capable of being kept in a state of fertility by being flooded with water from some adjoining river or stream. [IRRIGATION.]

Water Meter. An instrument for measuring the quantity of water which passes through it. Some water meters are constructed on the principle of a cylinder and piston, and each cylinder full of water that passes is registered by appropriate mechanism. Other kinds are formed on the principle of a patent log or windmill, by which the velocity of the water in the pipe is registered. No water meter hitherto introduced is free from objections, or has received wide acceptation.

Water Mill. A machine, driven by the reaction of water, sometimes called a *Barker's mill*. The most effective mill of this kind is that known as Whitelaw and Stirratt's, in which the velocity is governed by valves applied to the orifices of efflux to vary their size, thus correspondingly changing the quantity of water passing through the machine. These orifices are situated on the opposite sides of two revolving arms, and the velocity of rotation of these orifices should be made as nearly as possible the same as the velocity of the issuing water. The water is conducted into the horizontal revolving arms from below, through a watertight joint, and the upward pressure of the water balances the weight of the arms. In some cases the arms have been made in the form of an Archimedean spiral, but any other form does as well; the main condition being that the area of the arms shall be large relatively with that of the orifices. The water mill has been superseded to a great extent by the TURBINE.

Water Sapphire. A very pale-blue kind of Oriental Sapphire.

Water Supply. In Practical Geology, the quantity of water falling on any district in the form of rain, and finding its way to the interior of the earth in such a manner that it can afterwards be obtained and utilised. [SPRINGS, ARTESIAN; SPRINGS, NATURAL.]

It will be evident that the water supply must depend partly on the actual rainfall, partly on the fall of the ground, partly on the stratification of the rocks at their outcrop in the district, and partly on the nature of the rocks in the interior of the earth. Sands are always permeable in every part, but sandstones vary greatly; some being very open from cracks and bedding, others very tight and compact. Limestones are usually sufficiently cracked and broken near the surface to allow of much water to percolate, and within the earth they are almost always open, having many cavities and open fissures communicating with each other. Clays are almost always impermeable. They allow the water to run over them, and keep it back or conduct it according to circumstances.

The water supply of a district may be calculated within certain limits; but the calculation is liable to error, from the impossibility of knowing accurately the conditions of the earth's interior.

The supply of an abundant quantity of pure water to towns and cities has become one of the most important topics which can engage public attention. The connection of purity of the water used for domestic purposes with the condition of the public health has been proved most conclusively; and it is found that the ravages of epidemic disease in any district, and more especially of cholera, are wide-spread and fatal very nearly in the proportion of the impurity of water, especially in organic contamination, supplied for the use of the inhabitants. Up to the beginning of the present century, although water works existed in London and other great cities, most of the water required for the domestic uses of the inhabitants of towns, was drawn from wells by means of pumps, and even in London many public pumps still exist. But the changes in our domestic habits, which involved the construction of sewers for conducting away the refuse from every house, led to the contamination of the wells by infiltration from the sewers, and in most towns water is now supplied to the houses through pipes, by water works constructed for that purpose. The sources of supply, however, of most of these water works, are liable to contamination from the admixture of sewage; for many water works draw their supplies from rivers polluted by the sewage of towns situated higher up on the stream. Thus the water drawn from the Thames at Thames Ditton for the supply of a part of London has, before its arrival at that point, been polluted by the sewage of Oxford and other towns, and there are very few rivers in the country from which pure water can now be drawn. Even the water from many springs does not escape pollution from the infiltration of the rain which has passed through the manure spread over cultivated fields, and it consequently becomes important to derive the water required for the supply of towns from rocky or sandy districts bare of vegetation, where cultivation is not carried on. It is at the same time highly important that a comprehensive system of water works, embracing the whole kingdom, should be mapped out, to the end that the wants of the whole community may be represented, and that the same source of supply may not be fought for by several conflicting parties. Thus a scheme has been propounded for supplying Hull, and several other towns, with water from the lakes of Cumberland. But another scheme has been propounded for appropriating the water from those lakes to the supply of London. It is quite indispensable that London should be supplied from some pure and adequate source. But it is equally necessary that the claims of other districts should be considered; and it behoves the government, in the interest of the whole nation, to direct a survey to be made, which shall discover the natural and most eligible sources of supply for every town and city, and which other towns or cities, looking merely to their own local interests, should not be permitted to invade. There can be no doubt that as the water derived from the fall of rain on cultivated districts is impure, and as the area of rocky and arenaceous ground in the country is limited, the rain which falls upon those districts must not be suffered to run to waste in wet seasons, but must be impounded by the construction of great dams at suitable points of the valleys, so as to form reservoirs, or artificial lakes, in which the superfluous rainfall may be stored up. It is quite necessary that this question should now be dealt with in a practical and comprehensive manner. It behoves us to understand that the quantity of rain water which is free from contamination of some kind or other is no larger than we require, and that if it is to be sufficient for our uses it must be employed with judgment and economy. The habits incident to an advancing civilisation involve continually the consumption of a larger amount of water per head of the population, while manufactories, baths and washhouses, fountains, water for washing and watering the streets, as well as for working hydraulic cranes for hoisting goods, and for driving purposes generally, must also be taken into account in carrying out a system of water works.

In many of the towns of England, as well as on the Continent, the question of a larger and better supply of water is exciting much anxious thought. Liverpool and Hull, Paris, Florence, Berlin, Vienna and Leipsic are all either contemplating or prosecuting works having that end in view; and two great schemes have been propounded for the better supply of London, in one of which it is proposed to bring the water from the flanks of Cader Idris and Plynlimmon in North Wales, and in the other from the Cumberland or Westmoreland lakes. In

1850 the Board of Health reported that the total quantity of water delivered to London by the water companies was a little over 40,000,000 gallons per day. In 1856 the daily delivery was 81,000,000 gallons. In 1852, Acts of Parliament were passed which authorised the withdrawal from the Thames of 100,000,000 gallons daily, and it is believed that the amount now abstracted from the river is on an average about 60,000,000 gallons. In 1865 it is estimated that the eight London water companies delivered 108,000,000 gallons to 470,000 houses through 3,290 miles of pipes. This quantity of water, however, is quite insufficient for the legitimate wants of the inhabitants. In 1838 the quantity of water supplied to Glasgow by the old water works amounted to 26 gallons per head of the population. But in 1864, after the Gorbals and Loch Katrine gravitation works had been for some years in operation, the daily supply to a population of 485,000 persons was 22,500,000 gallons, or about 46 gallons per head of the population. The population of London in 1866, within a radius of fifteen miles from Charing Cross, was about 3,500,000; and if we take 50 gallons of water per head of the population as a fair allowance, the daily consumption should be 175,000,000 gallons; and making allowance for the rapid increase of population, no scheme proposing to supply less than 200,000,000 gallons daily could be considered adequate, and there must be means for increasing the supply to 250,000,000 gallons daily at no very distant period. The total quantity of water in the Thames which passed over Teddington weir in the dry season of 1864, was 380,000,000 gallons daily; so that for the water supply of London it is plain that a good-sized river of pure water is required.

In Mr. Bateman's scheme for supplying London with water from North Wales, the rainfall, though ascertained to be 45 inches in dry seasons, is taken at only 36 inches, and the drainage area consists of 130,572 acres, in two districts, of which the northern, consisting of 66,380 acres, is situated on the mountain range which includes the summits of Cader Idris and Aran Mowddy, and contains the sources of the Banw and Vyrnwy rivers, while the southern district, with an area of 64,192 acres, contains the source of the Severn. On the Vyrnwy it is proposed to form, by an embankment 76 feet high, a lake or great reservoir that will contain over 1,000,000,000 cubic feet of water, while on the river Banw two reservoirs are to be formed, one four miles long, with an embankment 80 feet high, containing 940,000,000 cubic feet, and the other, with a similar embankment, 732,000,000 cubic feet. To receive the drainage of the southern district there will be several reservoirs, of which the principal one, with an embankment 75 feet high, will contain 2,230,000,000 cubic feet of water. The total annual rainfall on these districts will be about 632,000,000 cubic yards, or about 104,000,000 gallons per day. But the aqueduct will be made capable of transmitting 220,000,000 gallons daily. The discharge pipes of the lowest reservoirs will be situated 450 feet above Trinity high-water mark.

The waters will be conducted by separate aqueducts to a point near Marten Mere, where they will be joined to a larger aqueduct running past Bridgenorth, Warwick, Banbury, Buckingham, and Watford, and terminating in large service reservoirs situated on the high ground near Stanmore. These reservoirs, which will be sufficiently large to hold ten days' supply, will be 250 feet above high-water mark, and from them the water will be conducted in pipes to London. The length of the branch aqueduct from the northern district to Marten Mere will be 19 miles, from the southern district to Marten Mere 21½ miles, and from Marten Mere to Stanmore 152 miles. The two branch aqueducts will each be capable of conveying 130,000,000 gallons daily, and the main aqueduct 220,000,000 gallons daily, as we have already stated. The area of the collecting ground can be increased wherever it may be found necessary. But it would be better to have this area large at once, and then to increase the supply by constructing reservoirs instead of by taking in more land, for which high terms might be required if left till it had become indispensable. At Bridgenorth the aqueduct will be carried across the Severn by means of siphon pipes, and the same expedient will be adopted for crossing the valleys of other rivers which the aqueduct has to pass. Between Bridgenorth and Watford the aqueduct will consist partly of open excavation and partly of tunnel or covered way, and its course will be such as to avoid the coalfields near the route, and also the salt-beds of Droitwich, to the north of which it will pass. The fall of the open portion will be 6 inches per mile, and of the covered portion 14 inches per mile. The total distance to be traversed by the water from the lowest reservoir on the Cader Idris branch before reaching London is 181 miles, and from the lowest reservoir on the Plynlimmon branch 183½ miles. The cost of the undertaking is estimated by Mr. Bateman at 8,600,000*l.*, of which over 1,000,000*l.* will be required for the construction of each of the branch aqueducts and its reservoirs, while the remainder will be required for the main aqueduct, the service reservoirs, and the connection of the pipes of the existing water companies with the new source of supply. The water in softness and purity is nearly the same as that supplied to Glasgow from Loch Katrine. The cost of new water works at Liverpool has been about 75,000*l.* for each 1,000,000 gallons per day delivered; at Manchester, 34,000*l.*; and at Glasgow, 45,000*l.* But if the sums which have been paid to previously existing companies be added, the amounts will rise to 115,115*l.*, 60,000*l.*, and 59,260*l.* respectively. The estimated cost of the proposed London works is 71,000*l.* per 1,000,000 gallons delivered daily so long as the delivery is 120,000,000. But it would

fall to 49,300*l.* when the full quantity which the aqueduct could transmit was supplied. Mr. Bateman considers that the capital required to construct the work might probably be raised at 4 per cent., that the management and repairs would cost 150,000*l.* per annum, and that 450,000*l.* per annum would pay their existing dividends to the existing water companies, making a total annual expense of 944,000*l.*, while a compulsory domestic rate of 10*d.* in the pound on the value of 12,000,000*l.* worth of dwelling-houses, and a public rate of 2*d.* on 18,000,000*l.*, with a revenue of 250,000*l.* per annum for the sale of water for trading purposes, and an annual value of 50,000*l.* of surplus property of existing companies which are to be absorbed, would make up a yearly income of 950,000*l.* At Manchester the rates now levied are 9*d.* in the pound for the domestic rate, and 3*d.* in the pound for the public rate.

In Messrs. Hemans and Hassard's scheme it is proposed to draw the supply from the Cumberland lakes, 240 miles distant, and to deliver it in London at a height of 220 feet above high-water mark. The area from which the water is to be collected is 177 square miles in extent, and of a mean altitude of 1,300 or 1,400 feet above the level of the sea. The whole district is bare hill pasture, and with the exception of a small area in the vicinity of Ullswater, which can easily be excluded from the scheme, is without mineral deposits. The mean annual rainfall is 100½ inches, but is taken at 80 inches, and the collecting area drains into the rivers Lowther and Greta, and into the lakes Haweswater, Ullswater, and Thirlmere. Storage would be provided in the lakes and in artificial works for over 5,000,000,000 gallons, or 120 days' supply at 250,000,000 gallons per day. From Ullswater the water would be drawn off through a tunnel 7¼ miles in length, which would be the only work of magnitude connected with the undertaking, and which would, it is estimated, be completed in about three years. The water would be conveyed to London by conduct tunnel and iron pipes, and would run nearly parallel with the North-Western Railway, delivering the water in a large reservoir at Harrow. The cost of the scheme for a daily supply of 250,000,000 gallons is set down as 12,200,000*l.* About 50,000,000 gallons, it is expected, would be disposed of to the towns on the line.

It must be remembered, however, that Mr. Dale, of the Hull corporation water works, proposes to employ the water of the Cumberland lakes to supply the towns in the north of England. Mr. Dale proposes to draw 150,000,000 gallons daily from these lakes through four cast-iron pipes of 6 feet diameter, which would extend as far as Leeds, 90 miles; three lines thence to Bolton, 55 miles; and two lines thence to Liverpool, 25 miles. Halifax, the highest town to be supplied, is 604 feet above the sea, Rochdale 472 feet, Burnley 492 feet, Huddersfield 429 feet, Bradford 420 feet, Keighley 388 feet, Blackburn 373 feet, Bolton 337 feet, Kendal 316 feet, Bingley 278 feet, Leeds 300 feet, Liverpool 227 feet, Wakefield 201 feet, Dewsbury 187 feet, Wigan 157 feet, Preston 140 feet, and Lancaster 132 feet. Mr. Dale's scheme, though sketched out at the end of 1865, was not published in detail till the end of September 1866, before which time Messrs. Hemans and Hassard's project had appeared.

It would be impossible within the limits of this article to notice in any detail the many important water works which are at present engaging public attention in the districts to which they belong; but we may remark that the water works of Paris embody a principle which may be carried out with advantage in every case where it is not easy to obtain large supplies of good water. There are two water services, the one of spring water for domestic, and the other of river water for watering and cleansing the streets, and for all other purposes for which it is suitable. Paris, with a population of 1,700,000 inhabitants, receives a supply of 240,000 cubic mètres, or 53,000,000 gallons per day, being about 31 gallons per day for each inhabitant. A further supply of 16,000 cubic mètres per day is expected so soon as the works which transmit the water of the river Dhuys are completed, and to this about 196,000 cubic mètres per day will, it is supposed, be added by bringing water from the sources of the Vanne, by pumping water from the Marne, and by sinking two new Artesian wells. Each street in Paris is by this system supplied by two different classes of pipes, an arrangement which might well be imitated in London; and if good water be brought from a distance to be transmitted through the existing pipes, the water of the existing water companies might be employed, when transmitted through a duplicate system of pipes, to perform all the functions which in Paris are performed by the river-water service.

The water of the Dhuys is brought to Paris by an aqueduct 134,000 mètres in length, of which part is a brick culvert, and part cast-iron pipes. The culvert, of which the cross section resembles an egg with the broad end downwards, is 1·4 mètre broad, and 1·76 mètre high. The principal source of the spring water is the Dhuys, the other sources being the springs of Arceuil, collected in the reservoir of the Pantheon and the Artesian well of Grenelle. The supply of river or coarser water is obtained by pumping from the canal of the Ourcq, and from the rivers Seine and Marne.

One of the most important points connected with the supply of water to towns consists in the accurate determination of the volumes of water which a given pipe or aqueduct with a given head or fall will transmit. The hydraulic mean depth of a stream is the area of the cross section, divided by the wetted perimeter; and if R be the hydraulic mean depth of the water in an aqueduct, I the inclination or declivity of the bed per foot run, and V the velocity of the water in feet per second, then $RI = aV + bV^2$, where a and b are constants determined by ex-

periment. Eytelwein has shown that the mean velocity of water flowing through uniform channels is very nearly $\frac{10}{11}$ that of a mean proportional between the hydraulic mean depth, and twice the fall in feet per English mile. If therefore H be the head or fall in feet per mile, then $V = \frac{10}{11}\sqrt{2RH}$. The velocity in feet per minute will be 60 times this, or it will be 54·54 times the amount obtained by multiplying the hydraulic mean depth by twice the fall in feet per mile. Mr. Beardmore in his Hydraulic Tables uses the coefficient 55 instead of 54·54. His rule is as follows:—

To determine the mean velocity with which water will flow through aqueducts, arterial drains, or pipes running partly or wholly filled:—

Rule. Multiply the hydraulic mean depth in feet by twice the fall in feet per mile; take the square root of the product, and multiply it by 55. The result is the mean velocity of the stream in feet per minute.

This again, multiplied by the sectional area in square feet, gives the discharge in cubic feet per minute.

In cylindrical pipes running full, the hydraulic mean depth is one-fourth of the diameter. For the hydraulic mean depth, being the area divided by the wetted perimeter, is in a full pipe $\frac{\cdot 7854\, d^2}{3\cdot 1416\, d} = \frac{d}{4}$.

M. Prony has shown, by comparing a large number of experiments, that if H be the head in feet per mile required to balance the friction, V the velocity of the water through the pipe in feet per second, and D the diameter of the pipe in feet, then $H = \frac{2\cdot 25\, V^2}{D}$.

This equation is identical with that used by Boulton and Watt since the commencement of the present century, and which is as follows:—

If l be the line of the main in miles, V the velocity of the water in the main in feet per second, D the diameter of the pipe in feet, and 2·25 a constant, then the head of water in feet necessary to overcome the friction will be $\frac{2\cdot 25\, l V^2}{D}$; in other words, there must be the number of feet in height of water indicated by this expression at one end of the pipe over the height at the other end to cause the water to run at the assumed velocity of flow. [Sewage; Water Meter; Water Works.]

Water Table. In Architecture, a projection or horizontal set-off in a wall, so placed as to throw off the water from the building.

Water Tables. In a ship, the sills of the windows in the stern.

Water Ways. Strong pieces of wood extending round the ship at the junction of the decks with the sides, to prevent the water entering between the edge of the deck and the ship's side; and also to counteract any tendency in the beams to slip upwards.

Water Wheel. In Hydraulics, an engine for raising water in large quantities. [Persian Wheel.] Also a wheel turned by the force of running water. Of these there are three kinds: the *undershot wheel*, the *overshot wheel*, and the *breast wheel*. In the case of the undershot wheel, the water strikes the float boards below the axle, and acts by the impulse due to its velocity. In the case of the overshot wheel, the water is brought over the top of the wheel, is received in buckets, and acts solely by its weight. In the case of the breast wheel, the water is received about midway up on the wheel, and acts chiefly by its weight, the float boards being made to run in a circular arc, which prevents the water from being spilt. Good overshot water wheels realise about 80 per cent. of the theoretical power of the water. But they are inconvenient from their large dimensions, especially in the case of high falls, and the turbine is now usually preferred. Breast wheels, if made with curved float boards on Poncelet's construction, are nearly as effective as overshot wheels.

Water Works. Works for supplying towns with water. The water is sometimes conducted at a high level from an elevated source by means of an aqueduct, and sometimes is pumped up from a well or river by a steam engine either into an elevated reservoir or directly into the distributing pipes. The pipe which conducts the water from the pump to the reservoir is called the *rising main*. In many water works a pipe called a *stand pipe* is introduced to supply water to houses standing at a higher level than the reservoir, the water being forced up into this pipe by the engine, while any excess not drawn off flows over through a bend into another upright pipe of the same height, and so escapes. In some water works there is no elevated reservoir, but the necessary hydrostatic pressure is obtained by forcing the water up into the stand pipe to the requisite height; in other cases, instead of a stand pipe, a safety valve properly loaded allows any excess of water to escape after the standard pressure has been reached. The engines for water works are now almost always double-acting rotative engines, and the pumps are usually of the bucket-and-plunger kind, first introduced by Mr. David Thomson in the Richmond water works in 1840. [Water Supply.]

Water-colour Painting. A species of painting or drawing, in which the medium of representation is colour levigated with water and gum, and which in our days has been carried to extraordinary perfection. Formerly all decorative work or limning was done in water-colours, i. e. the colours were tempered with a water vehicle, as gum, egg, size, or glue, milk, fig-sap, &c. These methods are, however, *tempera* or distemper methods, not pure water-colour painting, as in every case a *binder* is added to the water. Fresco, on the contrary, is a pure water-colour painting; so is also the new method of waterglass. [Fresco; Waterglass.] Not only all illumination or limning of manuscripts was executed in water-colours, but easel pictures also and large altar-pieces were executed in water in the middle

ages, and until the fifteenth century, when the old *tempera* vehicle was superseded by the varnish method of the Van Eycks, now commonly called *oil-painting*. Distilled water or filtered rain-water should be used; and gall and alcohol are also very serviceable; saccharine matter should be avoided, as it attracts the damp. [PAINTING.] On the best colours for water-painting, see Field's *Chromatography, or a Treatise on Colours and Pigments, and of their Powers in Painting*, 8vo. London 1841.

Water-cure. [HYDROPATHY.]

Water-lily. The common name for the species of *Nymphæa* and *Nuphar*, found in many of our streams, and greatly admired, especially the former, for its chaste beauty. An allied plant found in the waters of Guiana, called *Victoria regia* by botanists, is often called the royal water-lily.

Water-line. The boundary of any section of the bottom of a ship made by a plane parallel to the line of flotation. The uppermost one is called the *load water-line*; the lowest the *light water-line*.

Water-logged. A Nautical term, denoting the state of a ship when a quantity of water having been received into the hold by leaking, &c. she has lost her buoyancy, and yields to the effect of every wave passing over the deck.

Water-shed (Ger. wasserscheide, *water-parting*; the word *shed* is still used in Lincolnshire in the sense of *parting* or *dividing*). In Physical Geography, the natural surface drainage of a tract of land is grouped into a series of areas, called *river basins* or *drainage areas*, each of which is connected with some stream that enters the ocean or an inland sea. The dividing lines between such areas are called the *water-shed* or *water-parting*. It is not always the case, though most usual, that this line runs along a high ridge. It may cross a perfectly level tract or even a sheet of water. In South America the waters of two great drainage areas sometimes, but rarely, anastomose.

Water-weed. A name by which the *Anacharis Alsinastrum*, a pest of navigable streams, is sometimes known.

Watercress. A semi-aquatic herb found wild by the sides of brooks and in ditches, and much cultivated as a salad plant, especially for the supply of large towns, on account of its antiscorbutic properties. It is the *Nasturtium officinale*, and belongs to the order of Crucifers, many of which possess similar properties.

Waterfalls. Rivers in their course to the sea occasionally pass over rapid declivities, and sometimes fall over ledges of rock or precipices. Very frequently these have been originally produced or greatly increased and modified by the eroding action of the river itself. These are called *rapids* or *waterfalls*, as the water runs over obstacles on a slope or leaps down a precipice.

The most celebrated waterfalls in Europe are undoubtedly those of the Rhine, about two miles below Schaffhausen in Switzerland. The fame of these falls is, however, chiefly owing to the celebrity of the river, and to the mass of the stream, as the height is not great, varying from 50 to 60 feet according to the season. Other renowned waterfalls in Switzerland are: those of Handeck in the Oberhasli valley, where the Aar 'descends at a single bound of 200 feet into a dark chasm, whence clouds of spray ceaselessly arise, as if driven up by blasts from some subterraneous cavern;' and of the Staubbach, near Lauterbrunnen, a single shoot of about 900 feet. The fall of Gavarnie, in the Pyrenees, exceeds this in total height, but is broken on an intermediate ledge. On the whole, however, the falls of the Ache, near Krimml, on the boundary between Saltzburg and Tyrol, may be considered as the finest in the Alps; the stream, which has a considerable body of water, shoots down a height of about 2,000 feet in four leaps, the upper fall being one of about 700 feet. In Northern Europe the most celebrated falls are the Sarp-fos in Norway; the river Hommers, 120 feet wide, 27 feet deep, fall 75 feet; the Riukan-fos, 900 feet; and the Ostud-fos, 700 feet.

In Asia no very important falls have been described. In Africa the falls of the Zambesi are very remarkable. The river, which is large, leaps 100 feet into a ravine. The Ripon Falls, by which the Victoria Nile makes its way from the Victoria Nyanza to the Albert Nyanza, are very grand. The total difference of level is 600 feet. The Murchison falls of the Nile involve a leap of 120 feet, where the river is 50 yards wide and very deep.

In America the falls of Niagara are the most remarkable. The river is divided by an island. The American side is 375 yards wide, and the fall is 162 feet. The Canada fall is 700 yards wide and 149 feet deep. There are other important falls in the northern rivers, but none so considerable as these.

Waterglass. In Painting, a method of colouring lately discovered and established in Germany as a substitute for fresco. It is especially applicable for wall-painting. It is a pure water-colour painting on a porous or absorbent ground, of white plaster. After the wall is prepared with Portland cement and sand, it is covered with an intonaco or thin coat of fine plaster, containing three parts of fine sand—composed of carbonate of lime—and one of cement; this intonaco should be evenly worked by the mason, with a kind of tooth in the surface, by the use of a wooden hand float. The intonaco may be three of fine quartz sand and one of lime, such as is used in fresco-painting. The design may be traced on the wall when properly hardened; but the wall should be moistened immediately before painting. The colours are applied, mixed with distilled water, not heavily or in any great body, but thinly hatched over the surface. When the picture is finished, the whole is fixed by an application of the so-called *waterglass* from a syringe made expressly for the purpose, called a *sprinkler*.

The picture is thus indelibly fixed; hence the term *stereochromy*. Waterglass is a soluble alkaline silicate, a liquified flint, made by boiling silica in an alkali: it is sold in a liquid state, and is applied mixed with twice its quantity of water, one quart of the mixture being required to fix twenty square feet of painting. There are two kinds of waterglass, the one made with soda, the other with potash; the latter is found to be preferable. A picture thus fixed has no gloss, and can be seen in all lights. This method has been already successfully applied in the Houses of Parliament. (*Twelfth Report of the Commissioners on the Fine Arts*, 1861.)

Watering of Stuffs. This is a process to which silk and some other woven fabrics are subjected, in order to give a peculiar appearance to their surface, as seen by reflected light: it is generally done by passing the goods, in a damped state, between rollers, some of which are variously indented or engraved: sometimes the appearance depends upon the pressure of one fold of the stuff laid transversely or diagonally upon another, and powerfully pressed between plain revolving cylinders.

Waterlandians. In Ecclesiastical History, a division of the Dutch Anabaptists, also called *Gross* (Grob), or *Moderate*, in contradistinction to the *Fine*, or *Rigid*. They were so called from a district in North Holland denominated Waterland, and originated in the sixteenth century. John de Ries, in 1580, composed a confession of faith, which seems to have been pretty generally used among them. [GALENISTS; MENNONITES.]

Waterproofing. The process by which textile fabrics are rendered impervious to water. This is most perfectly effected by means of caoutchouc, which is applied in various ways; but there are other substances, and among them some of the earthy soaps, which are more or less effective, such, for instance, as a mixed solution of soap and alum, to which some gelatinous material is occasionally added.

Waterspout. A very remarkable meteorological phenomenon, observed for the most part at sea, but sometimes also on shore, though generally in the neighbourhood of water. Its general appearance may be described as follows: from a dense cloud, a conical pillar, which appears to consist of condensed vapour, is seen to descend, with the apex downwards. When over the sea, there are usually two cones; one projecting from the cloud, and the other from the water below it. These sometimes unite, and the junction has been observed to be accompanied with a flash of lightning; but more frequently they disperse before the junction is effected. In calm weather the column maintains its vertical position while carried along the surface; but when acted on by the wind it becomes oblique to the horizon. The causes of this meteor are very imperfectly known. By some it is supposed to be formed by a whirlwind of extreme intensity, while others ascribe it to an electric origin. (Young, *Nat. Phil.* vol. i.; Pouillet, *Elémens de Physique*, tome ii.) They are probably occasioned by the whirling of air with such velocity as to cause a vacuum in the axis of rotation; the contact of the lower end of such a vertical axis with water would cause the elevation of a column of the latter to a height of about thirty feet.

Wave (A.-Sax. wæg). The alternate elevation and depression of parts of the surface of a liquid above and below the natural level.

When the surface of a liquid is unequally pressed, the columns which sustain the greatest pressure are shortened, and sink below the original level; and the contiguous columns, being affected by the same pressure, will be lengthened and rise above that level. But as the elevation is not sustained by an hydraulic pressure, the lengthened columns again fall, and acquiring in the fall a velocity due to the height, descend below the original level, communicating in their turn a pressure to those which are adjacent to them. In this manner a reciprocating motion is produced, the particles to which the primitive impulse was communicated being alternately the lowest and the highest; the result is a series of ridges and hollows called *waves* or *undulations*.

In passing from the columns which are shortened to those which are lengthened, and back again to those to which they originally belonged, the particles of the fluid acquire both a vertical and horizontal motion; but while the depth is sufficient to allow the oscillations to proceed unimpeded, no progressive motion takes place, each column being kept in its place by the pressure of the surrounding columns. If, however, free oscillation be prevented (as by the shelving of the shore, or the interposition of a rock), the columns in the deep water are not balanced by those in the shallower, and thus they acquire a progressive motion towards the latter, or form *breakers*. For this reason, waves always break against the shore, whatever be the direction of the wind.

When waves are produced by the agitation of a small portion of the fluid, as for example by throwing a stone into stagnant water, they appear to advance from the disturbed point in expanding concentric circles, the height of the wave gradually diminishing as it recedes from the centre; but that there is no transference of any part of the mass from one place to another, is manifest from the motions of any light body floating on the surface. The appearance of progression is in fact an optical deception, produced by the form of the wave and the mode of oscillation. On attending closely to the phenomena it will be seen that the fore part is always in the act of rising, and the hinder part in the act of falling; and thus the whole system appears to roll onwards, while each particle of water in succession merely oscillates with a vertical ascent and descent.

If a second series of concentric waves takes

its origin from a different point at some distance from the first, the two sets will cross each other without the slightest interruption. Where a wave of the first series meets one of the second, and the two elevations correspond, the resulting elevation will be equal to the sum of the two; and the same is the case with the depressions. Where the elevation in the one series corresponds with a depression in the other, the surface will maintain its original level, at least if the waves of the two series have the same height. Thus, although different series of waves do not interfere with each other's propagation, they may nevertheless increase or neutralise each other's effects. The one series is, in fact, superposed on the other.

A series of waves meeting a vertical obstacle, as a wall or bank, is reflected; and the reflected waves are propagated in the same manner as those arising from the original impulse, but in an opposite direction. Waves proceeding in concentric circles are reflected in concentric circles, in such a manner as to diverge apparently from a centre as far behind the obstacle as the original centre is in front of it; they appear, in short, to be subjected to all those laws which are usually noticed to belong to reflected light.

If the obstacle against which the waves strike have an opening in it of small horizontal breadth relatively to the breadth of the wave, the oscillating columns which reach it will act as an impulse originally exerted at that point, and a series of waves will diverge from the aperture as from a new centre; but when the aperture is considerably wider than the wave, the wave confines its motion in a great measure to its original direction, though with some small divergence, or the oscillation is continued principally in the direction of a sector, whose centre is at the point from which the original wave proceeded.

Waves which have been raised by the wind in the open sea proceed in parallel and nearly straight lines; and the original impulse being increased by the continual action of the wind, they will increase in height until the weight of the elevated column, together with the friction, becomes equal to the inciting cause. It has been inferred that the greatest height to which a single series of waves raised by the wind blowing constantly in one direction will attain does not exceed six feet. But several series of waves moving with different velocities may co-exist upon the ocean, and thus the crests of two or even three waves may be superimposed upon each other, producing the *tremendous seas*, three of which are usually succeeded by comparatively smooth water, because the hollows of the one series are then filled up by the crests of the other. The force of the wind also tends to give a progressive motion to the mass of water raised above the general level, and likewise to alter the shape of the wave by diminishing the acclivity of the side against which it strikes. In a strong gale this effect may be increased so far as to cause the top of the wave to project over the base, in which case it breaks and rolls over on the preceding wave. Hence, as sailors well know, a very strong wind will blow the sea down.

If the wind, after having given rise to a series of waves, suddenly veers about so as to strike waves on the opposite side, it will produce a greater effect from its more direct impact; and hence the greatest waves are produced by sudden changes of wind, or by the wind blowing in an opposite direction to that in which the waves are propagated. In this manner the elevation of the waves may be greatly increased above the height to which they would be raised by winds of equal force blowing constantly in the same direction. Hence the ocean is comparatively smooth in regions where the winds are constant; and as it is by the friction of the wind on the water that the waves are raised and kept up, whatever diminishes the friction will tend to lessen the elevation. Hence the comparative tranquillity produced by pouring oil on agitated water.

Wave-offering. In the Old Testament (Ex. xxix., Lev., and Num.), an offering which when held aloft by the priest was *waved*, signifying symbolically that it might be eaten by the worshippers: whereas such as were *heaved* were appropriated to the priests.

Wavellite. A hydrated phosphate of alumina, found generally in small crystals forming hemispherical or globular concretions with a radiated structure. It is met with at St. Austell in Cornwall, on the clay-slate of Barnstaple in Devonshire, near Freiberg in Saxony, in Bohemia, &c. It is named after Dr. Wavell, the discoverer.

Wax (A.-Sax. wæx, Ger. wachs). This is a common vegetable product, forming the varnish which coats the leaves of certain plants and trees. It is also found upon some berries, as of the *Myrica cerifera*; and it is an ingredient of the pollen of flowers. It was long supposed that bees merely collected the wax thus ready formed in plants; but Huber found that though excluded from all food except sugar, they still formed wax; and accordingly it has been found that the elementary composition of bees' wax and vegetable wax is slightly different. Bees' wax is prepared by draining and washing the honeycomb, which is then melted in boiling water, strained, and cast into cakes. English wax and foreign wax are found in the market; the latter being chiefly imported from the Baltic, the Levant, and the coast of Barbary. Fresh wax has a peculiar honey-like odour: its specific gravity is ·96. At about 150° it fuses, and at a high temperature volatilises, and burns with a bright white flame. It is bleached by being exposed in thin slices or ribands to light, air, and moisture, or more rapidly by the action of chlorine; but in the latter case it does not answer for the manufacture of candles, which is one of its principal applications. Wax candles are made by suspending the wicks upon a hoop over the cauldron of melted wax, which

is successively poured over them from a ladle till they have acquired the proper size, so that the candle consists of a series of layers of wax; the upper end is then shaped, and the lower cut off. Bleached or white wax is generally adulterated with more or less spermaceti, and sold at different prices accordingly; in this case it has not the peculiar lustre of pure wax, and is softer and more fusible. It is also largely adulterated with stearin or stearic acid, which is detected by the odour of fat or tallow which it evolves when highly heated, and by its crumbly texture; it may also be separated to a certain extent by ether or alcohol. Wax is insoluble in water, and scarcely acted upon by the acids, so that it forms a good lute or cement: boiling alcohol and ether partially dissolve it, and deposit the portion which they had dissolved on cooling. According to Brodie (*Phil. Trans.* 1847–49), bees' wax contains three substances separable by boiling alcohol, viz. *myricin* ($C_{92}H_{92}O_4$), which is insoluble; *cerin* ($C_{54}H_{54}O_4$), which is deposited in crystals as the solution cools; and *cerolein*, which is retained in solution. Their relative proportions vary, but in ordinary bees' wax there appears to be about 73 per cent. of myricin, 22 of cerin, and 5 of cerolein. [APIS; HIVES, BEE.]

Wax Opal. An inferior kind of Common Opal.

Wax-modelling. Wax is a substance formerly much used by sculptors in forming their models, and still greatly used by silversmiths. The founder's wax was commonly mixed with a little tallow, turpentine, and pitch, the quantity of wax being about ten to one of each of the other ingredients. Wax was especially used for hollow casting: when the safe-mould from the model was completed, it was filled in to a certain thickness with wax, and fixed, properly supported, in its place; the remaining cavity was then filled from the top with a fire-proof composition of plaster and brick-dust, to form a *core*. The mould was now removed, and a complete wax model showed itself; this the sculptor carefully revised, and again covered with a fire-proof mould of plaster, brick-dust, cowhair, and horsedung, put on with a brush in various layers; when it had reached a sufficient thickness, and was properly supported, a coal fire was kindled round it, and vents being prepared, every particle of wax was burnt out of it—a very anxious and tedious process. The whole was then bricked up and the pit filled with sand; the molten metal then took the place of the wax, and the cast was accomplished. Clay and sand modelling has now generally superseded this old wax method. A very simple mode of taking a wax cast is, to invert the mould in cold water, thus giving it a cold damp surface which instantly chills the molten wax poured into it at the points of contact, while the main bulk, remaining in a liquid state, will run out again as soon as the mould is turned over, giving the desired wax shell. This shell must then be filled in with a core, and proceeded with as above.

Another kind of wax modelling is the so-called *ceroplastic* art, i.e. modelling and casting in wax itself, not merely using the wax as a means of producing casts in other substances. To this class belong wax images; wax fruit and flowers, together with the wax anatomical and pathological models, now much in vogue, and of which many extraordinary examples exist in Florence, Paris, and London. Nearly all these wax models are cast from moulds; the mould may be in plaster of Paris, or a composition of bees' wax, Burgundy pitch, and Venice turpentine, with a very little olive oil. This composition has the great advantage of being *elastic*, and when thin can be peeled off the cast.

Wax images also are made by casting, but a cheap method is to mould the face in paper pulp and size, paint this mask in strong local colours, and then cover with two or three coats of fine wax: the colours will show through the wax, and the mask will require only the eyes and hair to be added; local effects can be modified by painting with wax and turpentine. (Wornum 'On Wax-modelling' in the Supplement to the *Penny Cyclopædia*.)

Way (A.-Sax. weg). The Sea term for progress. A ship in progress is said to have *way* upon her; when stationary, to have no *way*. Steering power is proportionate to *way*.

Ways and Means. When the House of Commons goes into committee of the whole house for the purpose of considering the manner in which funds are to be raised for the public expenditure, it is said to go into committee of ways and means.

Wayfaring-tree. A common name for *Viburnum Lantana*.

Wealden Formation. The name given in Geology to certain deposits occurring in England in the Weald or Wolds (wooded portions) of Kent, and hence to other contemporaneous rocks elsewhere. The Wealden deposits occur between the oolitic and cretaceous series. They are in England almost entirely of fresh-water origin, and include clays, sandstones, and limestones. The following is the series:—

1. *Weald Clay* of Surrey, Kent, and Sussex, with *Cypris*. Fresh water.
2. *Hastings Sands*. Tunbridge and Ashburton beds, separated by the Wadhurst clay and Ashdown sands, containing calc grit. Notwithstanding the name, the argillaceous element preponderates over the sand in this division as well as the other.
3. *Purbeck beds*. The Wealden beds have been traced for about 200 miles from east to west, and about the same distance from north-west to south-east. They probably represent a large delta, not, however, larger than many existing river deltas.

In English Geology it is always usual to treat this formation as distinct and interpolated. Its representatives in time certainly connect themselves either with the overlying or under-

lying marine formations of other countries, though it is not always possible to say with which.

The Wealden series in the typical Wealden district of England consists of the deposits called HASTINGS SANDS, which repose on the PURBECK STRATA. The uppermost member is the WEALD CLAY, a well-defined argillaceous band, loaded with minute cases of the bivalve crustaceans, and reaching round between the chalk and the Hastings sands. Between the sands and the clays, however, are sandstones and shelly limestones, the latter of which include a bed capable of taking a polish, and known as the *Sussex marble*. This bed is very characteristic. Among the limestones are valuable ironstones.

The Wealden series has always been regarded as the accumulations made at the mouth of a considerable river coming in from the west. The deposits extend, but are very poorly exhibited, across the Channel on the coast of France near Boulogne; and beds distinctly contemporaneous are found in Scotland, Westphalia, and Hanover. The latter are important from their magnitude and thickness. They consist of sandstones.

The *denudation of the Weald*, or the laying bare of the tract in which these river deposits are present, is a remarkable and interesting geological phenomenon. [VALLEY OF ELEVATION.] The chalk has once covered the whole of the Wealden deposits, has been lifted up and fractured along a line apparently nearly parallel to that of the course of the ancient river, and then washed away for a space on each side of the fracture. It now forms two escarpments facing each other, with the Hastings sand occupying the intervening valley. The Hastings sand, much lower in geological position, is higher in some places than the general level of the top of the chalk hills on each side. The time occupied in the elevation was probably very great; and the work of carrying away the disturbed rock was likewise spread over a very long period, and was exceedingly gradual.

The Wealden beds are interesting as containing the remains of gigantic herbivorous land reptiles, and also of the flying reptiles of the oolite, lias, and chalk.

Wealth (from *weal*; A.-Sax. welga, *rich*). In Political Economy, this term denotes such objects and services as are in demand in any community, and which are the products of labour. Natural qualities, as unworked mines or unappropriated forces, are not wealth, except metaphorically. Nor is labour wealth, except it be called effectively into activity by demand. But all products which can be measured by some standard of value are wealth, whether they be material objects, or that kind of labour which either directly or indirectly contributes to the production of objects in demand. Most economists, while they readily acknowledge the claim of material objects to the name of wealth, ignore or deny the right of labour to the title, though they sometimes admit that mechanical labour is part of public wealth. But it is difficult to see how manual labour can be called wealth, and mental labour be treated differently. Of course by labour is meant the concrete notion, i.e. the persons of those who proffer services. Money is wealth only in so far as it is the requisite machinery of commerce. Hence those communities which are best informed of the nature of money seek to diminish the amount of money which they employ to the least possible amount consistent with the convenience of exchange. The theory that money is wealth per se, was the enduring fallacy of past times. Nor again, when the aggregate of national wealth is estimated, must the rent of the natural powers of the soil and public debts be treated as wealth. They are both deductions from wealth, the former being consequent on the pressure of population, the latter being a mortgage on the future productiveness of the community.' Some, however, who have attempted to reckon the amount of national wealth, have carelessly included these elements.

National wealth is not a quantity, but a ratio. In the middle ages, Genoa and Venice were esteemed wealthy, and were really so. But it is probable that even taking into account the different value of money, the imports and exports of either of these cities did not equal those of a third-rate British port at the present time. Again, the phenomena of wealth may dazzle the eyes of those who consider a social state superficially, while the reality is something quite different. For ages the estimate of the riches of Hindustan was exaggerated by the wealth of a few potentates. Later experience has shown that the country is really very poor, for although it contains so many millions of inhabitants as to be nearly ten times as populous as England, the possible revenue which may be extracted from the people is comparatively small; while the capital which may be engaged in industrial pursuits needs, even for the most manifest public advantages, the aid of British savings.

Nations do not become wealthy by isolation, nor is the prosperity of a neighbouring country any weakness to another. On the contrary, the growth of foreign wealth is an indirect aid to the developement of prosperity at home. The delusion that one nation's gain is another's loss has been the fruitful cause of international jealousy and destructive wars. [POLITICAL ECONOMY.]

Again, the distribution of wealth is as important an object for economical consideration, as its production; for those nations only are permanently prosperous, in which facilities are given for the free developement of wealth among all members of the community. [CAPITAL; DISTRIBUTION; PROFIT.]

Wear or **Weir** (A.-Sax. wer). A dam in a river, sometimes formed by driving in rows of piles and weaving branches between them, filling up the interstices between the rows with stones.

WEAR. To put a ship on the other tack, by bringing her round with her stern to the wind. [VEER.]

Weather (A.-Sax. weder, Ger. wetter). The state or condition of the atmosphere, with respect to heat, cold, dryness, moisture, wind, rain, snow, fogs, &c. The various causes which determine the state of the atmosphere, and produce those changes which are incessantly taking place in its condition, and which are popularly called the *weather*, form the subjects of METEOROLOGY and CLIMATE. [ATMOSPHERE; BAROMETER; CLOUD; DEW; HAIL; HYGROMETRY; RAIN; WIND, &c.]

In all ages of the world, mankind have attempted to explain and prognosticate the changes of the weather; but such is the complication of the subject, and so great the multitude of circumstances to be taken into account, that no theory can furnish rules for determining the order in which they succeed each other, or for predicting the state of the weather at a distant future time with any approach to certainty. Nevertheless, all the different modifications of the atmosphere are the necessary results of principles, not only fixed and unalterable in their nature, but (many of them at least) well known in their separate and individual operation. The difficulty of tracing the results of their combined influences arises chiefly from their complexity and endless concatenation.

The principal cause of all the variations which take place in the state of the atmosphere is the heating action of the sun's rays; but in order to appreciate correctly the effect of this action, we must know not only the extent of the atmosphere, but the properties of all the substances of which it is composed. Modern science has discovered that the atmosphere is composed of three different gaseous fluids, everywhere combined in the same proportions, and penetrated by an ever-varying quantity of elastic vapour. These two distinct envelopes of air and vapour mechanically mixed have different relations to heat; and therefore, in consequence of the unequal temperature of the surface of the earth with which they are in contact, they cannot both be in a state of equilibrium at the same time. Owing to the diurnal rotation, the different parts of the atmosphere are constantly receiving different quantities of heat, as the solar rays penetrate more or less obliquely. This inequality of temperature produces wind, which, if the surface of the earth were perfectly regular and homogeneous, would always blow in the same direction; but as the surface of the earth is composed of materials of various kinds, and irregularly disposed, the distribution of heat over it is extremely irregular. The winds, sweeping along the surface, acquire its temperature; and hence the atmosphere also becomes irregularly heated. This produces an accumulation of air at one place, and a deficiency at another; and hence a subsequent rush to restore the equilibrium. As the air is cooled, it becomes also incapable of holding the same quantity of aqueous vapour, a portion of which is therefore set free, and gives rise to clouds, mist, rain, dew, snow, &c. Besides all this, we have to consider the developement of electricity; the disturbance of the atmosphere produced by the rise and fall of the tides; and there may then remain probably many other circumstances with which we are entirely unacquainted. This very imperfect enumeration may serve to give an idea of the difficulties to be overcome in forming a theory of the weather. [CLIMATE.]

It has always been a favourite prejudice that the weather is influenced in some mysterious manner by the moon. The moon can be supposed to act on the earth only in one of three ways; viz. by the solar rays which it reflects; by its attraction; or by an emanation of some unknown kind. Now, the light of the moon does not amount to $\frac{1}{100000}$ that of the sun; and the heat which it excites is so small as to be altogether inappreciable by the most delicate instruments, or the best devised experiments. With regard to the attraction of the moon, we see its influence on the tides of the ocean, and might therefore be disposed to allow it a similar influence on the atmosphere; but when we take into account the small specific gravity of atmospheric air in comparison with water, and the consequent smallness of the mass of matter to be acted upon, it will readily be perceived that this influence also must be extremely feeble. In fact, it has been demonstrated by Laplace, that the joint action of the solar and lunar attraction is incapable of producing more than an atmospheric tide flowing westward at the rate of about four miles a day, and this is scarcely, if at all, appreciable. As to the remaining supposition, that the moon may act on the atmosphere by some obscure emanation, it is sufficient to remark that no meteorological observations that have yet been made afford the slightest traces of any such connection between the earth and its satellite. The registers which are now kept in various observatories and other places also prove, contrary to the popular belief, that the changes of weather are in no way whatever dependent on the lunar phases. (*Annuaire du Bureau des Longitudes* for 1833; Kämptz, *Lehrbuch der Meteorologie*, and Walker's *Translation*; Schubler, *Einfluss des Mondes auf die Veränderung unserer Atmosphare*, Leipzig 1830; *Greenwich Meteor. Obs.*)

WEATHER. The Sea term for that side on which the wind blows. *To weather* is to pass to windward of an object.

Weather Boarding. In Architecture, feather-edged boarding nailed upright, the boards lapping over each other.

Weather Gage. A ship to windward of another is said to have the weather gage of her.

Weather Glass. A name commonly given to the BAROMETER; but sometimes also applied to other instruments for ascertaining the state of the atmosphere, or measuring atmospheric changes. It is thus applied to the various forms of the HYGROMETER.

Weathering of Rocks. The destruction and change of form produced on rocks by the

action of the weather All rocks are subject to this, and in some countries the effects are much greater than in others. Limestones are thus rendered highly picturesque, for they are acted on by the water in two ways, mechanical and chemical, the water dissolving out the limestone and undermining it; so that falls are frequent. The direct action on many kinds of sandstone is very great, as here also the water penetrates crevices and undermines the rock. On clays the result is yet more considerable.

Granite among the crystalline rocks shows remarkable instances of weathering in most countries. The *tors* of the west of England are some of them very good illustrations. One, called the *Cheesewring*, near Liskeard, consists of five blocks, of which the upper are larger than the lower, the whole pile being about fifteen feet high. The stones composing this and other similar piles suffer by the action of the weather most rapidly upon their edges and angles, which gradually become rounded, and the blocks then begin to totter and ultimately to fall. This tendency of square blocks to become spheroidal, which has sometimes been mistaken for the effect of friction, shows that attrition and transportation by streams are not always essential to their rounded appearance. The celebrated *Logging-stone* well exhibits the tendency of this kind of granite to cuboidal separation.

Cheesewring.

Weavers or **Textoriae.** The name of a tribe of spiders including those which fabricate webs in order to entrap their prey.

Weaving (Ger. weberei; the word appears in the Greek ὑφή, Sansc. vap, *a web*). An operation by which threads are formed into cloth by a process resembling darning. The loom by which weaving is accomplished is merely an instrument which enables the darning to be performed with a smaller expenditure of time and labour than would otherwise be required. The species of loom at present used by the natives of India is probably its most primitive form. Yet with this rude instrument the most delicate fabrics are produced, and it is mainly by increasing the rapidity of production rather than by improving the quality of the product, that the present generation of weavers has been enabled to excel the ancients in this department of industry. The Indian loom consists substantially of two horizontal rollers of bamboo between which the threads called the warp are stretched. Each alternate thread is raised by being attached by a loop to a vertical string which pulls it up, leaving a space between the layers through which a great wooden needle and thread, or *shuttle* as we call it, is projected, when the threads before raised are let down and the others raised, so that the same process of transmitting the shuttle may be again repeated. In this way, the fabric of cloth is built or darned up, thread by thread, and it is wound up on one of the rollers as it is completed, while a corresponding length of threads is unwound from the other roller in readiness to be transformed into cloth in its turn. In modern looms, the parts are all accurately made of iron and wood, and are so constructed that the process of weaving may be carried on with great rapidity. Apparatus has also been introduced, in some cases of a very complicated character, to enable figures and colours of different kinds to be interwoven in the cloth. But the principle of all existing looms is substantially that of a darning machine.

In the Indian looms and in the old loom used in this country, the shuttle was thrown from one side of the web to the other. But, about 1740, the *fly shuttle* was introduced by John Kay, of Bury. By this contrivance the shuttle was driven from side to side of the web by means of a handle wrought by the weaver's right hand, while the left gave motion to a swinging frame. The *power* loom is driven by steam. The chief peculiarity of the *pneumatic* loom is that the shuttle is shot from side to side by a blast of compressed air. All reciprocating looms, however, are defective, and the want now to be supplied is to construct a circular or revolving loom, in which the shuttle, instead of being driven backward and forward, should be impelled onward continously. It appears probable that a new form of loom may be introduced, in which the operations of the sewing machine will be imitated instead of that of simple darning; and the practical introduction of circular weaving may be thus promoted. In the *stocking* loom circular weaving has been already largely introduced. In the Jacquard loom, a chain of perforated cards is made to pass over a drum, and the strings by which the threads of the warp are raised pass over a pulley or edge with a leaden weight of small diameter hanging at the bottom of each. These weights at each stroke of the loom are presented to each successive card, and some of them are intercepted by the card, while others pass through holes in the card, so that by the holes in the card the particular threads of the warp which are raised for the weft to pass through are determined. In this way, the nature of the figure on the cards determines the nature of the figure on the fabic. The Jacquard loom is a modification of the old Damascus loom, in which the fabrics called *damasks* were first manufactured, with this difference only, that in the Damascus loom the pattern was produced by the skill of the workman, and perforated cards were not employed.

Websterite. The native subsulphate of alumina; named in memory of Webster the geologist. It occurs in white or yellowish-white reniform masses and botryoidal concretions, in a layer of ochreous clay, in the cliffs at Newhaven on the coast of Sussex, and in potholes in the chalk near Hove in the same county.

Wedge (A.-Sax. wecg). In Geometry, a solid having five sides or faces, three of which are rectangles, and the remaining two consequently triangles, and parallel to each other; hence the wedge, considered as a geometrical figure, is a prism with a triangular base. Its content is therefore equal to the area of the triangular base multiplied into the distance between the parallel planes.

Wedge. In Mechanics, this term denotes one of the five simple engines or mechanical powers, used sometimes for raising bodies, but more frequently for dividing or splitting them. In the former case, if we suppose the wedge to be urged by pressure, the action of the wedge is precisely the same as that of the inclined plane; for in point of mechanical advantage it clearly makes no difference whether the wedge be pushed under the load, or the load be drawn over the plane. The power is therefore to the force to be overcome as the tangent of the angle of the penetrating sides to the radius, leaving the friction out of consideration: hence the thinner the wedge, the greater is its effect. But when the wedge, as is generally the case, is driven forward by percussion, its power cannot be estimated exactly. The percussive tremor excited by the blow destroys for an instant the friction at the sides, and augments prodigiously the penetrating effect. Besides, when the wedge is used in rending wood or other substances, the parts of the block are generally separated to a considerable distance before the edge of the wedge, as in the annexed figure; in which case

it further acts as a lever, the power being applied at the end of the block or acting part of the wedge, and the resistance being at the point where the fibres begin to separate.

All the various kinds of cutting and piercing tools, as axes, knives, scissors, chisels, nails, pins, awls, &c., are modifications of the wedge. The angle in these cases is more or less acute, according to the purpose to which it is applied. The mechanical advantage is increased by diminishing the angle of the wedge; but the strength of the tool is thereby also diminished. In tools for cutting wood the angle is generally about 30°; for iron it is from 50° to 60°; and for brass from 80° to 90°. In general, the softer the substance to be divided, the more acute may the wedge be constructed.

Wedge Gun. [Rifled Guns.]

Wednesday. The fourth day of the week, consecrated to Odin or Woden. The Romans called it dies Mercurii, whence the French Mercredi.

Week (A.-Sax. weoc). A period of seven days, of uncertain origin, but which has been used from time immemorial in Eastern countries. The week did not enter into the calendar of the Greeks, who divided the civil month into three periods of ten days each; and it was not introduced at Rome till after the reign of Theodosius. The use of weeks, according to some writers, was suggested by the phases of the moon, while others refer its origin to the seven planets known in ancient times, and thus explain the circumstance that the days of the week have been universally named after the planets, according to a particular order. [Calendar.]

Wehrlite. A massive variety of Lievrite from Szurzaskő in Hungary; named after the Austrian councillor Wehrle.

Weigh (A.-Sax. wægan, Lat. veho). To lift the anchor out of the ground.

Weight. In Algebra. [Resultant.]

Weight. In Commerce and Experimental Philosophy, the measure of the force by which any body, or a given portion of any substance, gravitates to the earth. The process by which this measure is obtained is called *weighing*; and when required, as in many philosophical experiments, to be performed with great accuracy, is a tedious and delicate operation. [Balance.]

The determination of weight, like that of extension, consists in the comparison of the thing to be measured with some conventional standard. But it is impossible to fix such a standard by written law or oral description; for it is impossible to communicate by words, and without reference to a sensible object, any adequate idea of a pound-weight, or foot-rule. Standards of linear measure, not accurately defined indeed, but having an average value sufficiently well known for the rude purposes of mankind in the early stages of society, were furnished by the different parts of the human body; hence the measures *foot*, *cubit*, *span*, *pace*, &c. [Measures.] But the method of comparing the weights of bodies does not suggest itself so readily to the mind as the comparison of linear dimension, and is not so easily accomplished. A balance is necessary, the construction of which requires some degree of mechanical knowledge. Hence the art of weighing, though of great antiquity (Goguet, *Origine des Lois*, &c.) was probably practised at a later period, and in a still less accurate manner, than that of measuring. There has also been a much greater variety of standards of weight, still less definite than those of measure, as will be readily conceived by considering the origin and import of such terms as *stone*, *load*, *last*, &c. The term *pound* (pondus) implies only weight indefinitely. The *grain*, as a standard of small weight, being taken from the grains or corns of wheat, was perhaps the only denomination of weight that would universally convey anything like a precise idea.

As there is a constant ratio between the volumes and weights of the same substances when placed in the same physical circumstances, it is obvious that standards of weight may be derived from those of measure. For example, a cubic foot or a cubic inch of distilled water, at the same temperature, and under the same atmospheric pressure, will always have the same weight. Advantage has been taken of this property of bodies to connect weights with

measures in the metrical systems that have been adopted in this and other countries.

English Weights.—It was declared by the Great Charter that the weights should be the same all over England, but no ordinance, perhaps, was ever so ill observed; for the diversity that has prevailed, and which is still far from being remedied, has been so great as not only to produce confusion and inconvenience, but to render the system of weights adopted in one part of the country scarcely intelligible in another. The old English pound, which is said to have been the legal standard of weight from the time of William the Conqueror to that of Henry VII., was derived from the weight of grains of wheat: 32 grains gathered from the middle of the ear and well dried made a pennyweight, 20 pennyweights an ounce, and 12 ounces a pound. Henry VII. altered this weight, and introduced the *troy* pound instead, which was $\frac{1}{15}$ (or $\frac{3}{4}$ of an ounce) heavier than the old English pound. The troy pound was divided in the same manner as the old English pound, into ounces, pennyweights, and grains; but the pennyweight contained only 24 grains, and consequently a grain troy became a much heavier weight than the grain of wheat. In fact, the pound troy contains 5,760 grains, while the Saxon pound, which was divided into 7,680 grains, contained only 5,400 troy grains. Another weight, the *avoirdupois* pound, was introduced by a statute of 24 Henry VIII.; and though its first object was that of weighing butchers' meat in the market, it has gradually come to be used for all kinds of coarse goods or merchandise. Two legal measures of weight were thus established, and have continued to be used in the country ever since; the avoirdupois weight being used for common purposes, and the troy for the precious metals, and, with a different division, by apothecaries in compounding their drugs. The standard of these measures was at length definitely fixed by the Act of Parliament 5 Geo. IV. c. 74, entitled 'An Act for ascertaining and establishing Uniformity of Weights and Measures,' which has been amended by several subsequent statutes. The following are the terms in which the standard is defined by the Act: 'That from and after the first day of May, 1825, the standard brass weight of one pound troy weight made in the year 1758, now in the custody of the clerk of the House of Commons, shall be, and the same is hereby declared to be, the original and genuine standard measure of weight; and that such brass weight shall be, and is hereby denominated, the imperial standard troy pound; and shall be, and the same is hereby declared to be, the unit or only standard measure of weight, from which all all other weights shall be derived, computed, and ascertained; and that $\frac{1}{12}$ part of the said troy pound shall be an ounce, and that $\frac{1}{20}$ part of such ounce shall be a pennyweight, and $\frac{1}{24}$ part of such pennyweight shall be a grain, so that 5,760 such grains shall be a troy pound; and that 7,000 such grains shall be, and they are hereby declared to be, a pound avoirdupois, and that $\frac{1}{16}$ part of the said pound avoirdupois shall be an ounce avoirdupois, and that $\frac{1}{16}$ part of such ounce shall be a dram.'

It follows from this that the weight of the pound troy to that of the pound avoirdupois, or common pound, is in the proportion of 5,760 to 7,000, or of 144 to 175. The use of two different systems of weights was retained in compliance with the common usages of the country; and the motives which influenced the commissioners of weights and measures in recommending the system which has been adopted were thus explained by Mr. Davies Gilbert: 'The troy pound appeared to us to be the ancient weight of this kingdom, having, as we have reason to suppose, existed in the same state in the time of Edward the Confessor; and there are reasons, moreover, to believe that the word *troy* has no reference to any town in France, but rather to the monkish name given to London, of Troy Novant, founded on the legend of Brute. Troy weight, therefore, according to this etymology, is, in fact, London weight. We were induced, moreover, to preserve the troy weight, because all the coinage has uniformly been regulated by it; and all medical prescriptions and formulæ now are, and always have been, estimated by troy weight, under a peculiar subdivision which the College of Physicians have expressed themselves most anxious to preserve.'

In the sixth clause of the Act it is enacted, that if the standard troy pound should be lost or destroyed, it is to be restored by a reference to a cubic inch of distilled water, which has been found and is declared to be 252·458 troy grains, at the temperature of 62° of Fahrenheit, the barometer being at 30 inches. Hence the weight of a pennyweight troy is to that of a cubic inch of distilled water, in such circumstances, in the proportion of 24 to 252·458, or of 24,000 to 252,458; so that the weight of the cubic inch of distilled water must be conceived to be divided into 252,458 equal parts, and 24,000 of such parts will be the standard pennyweight; or 240 of such pennyweights will be the standard pound. The Acts 4 & 5 Wm. IV. c. 49, and 5 & 6 Wm. IV. c. 63, made no alteration in the method of recovering the standard.

In 1843, a committee consisting of several eminent authorities was appointed. Their report, signed by all the surviving members, was published in 1854. The committee determined to take the avoirdupois pound of 7,000 grains as a standard, and to construct the troy pound from it. They took the brass troy pounds in the possession of the Exchequer, and certain *platinum* pounds in the possession of the Royal Society and others. The former were found to have gained in weight by oxidation, and the platinum pounds only were used. From them a platinum pound was prepared weighing in vacuo 6,999·99845 grains. The form of the weight is a cylinder, with a groove surrounding it a little above the middle of its height for the

insertion of the ivory fork used in lifting it. The weight is enclosed in a mahogany box, the parts of which when screwed together cause the weight to be immovable. This box is enclosed in another box, and with the standard yard in a third box, and finally in a stone case in the vaulted stone room of the Exchequer. The proceedings of the committee received the sanction of the legislature by 18 & 19 Vict. c. 72.

For philosophical purposes and in delicate weighing, troy weight only is used, and the weight is usually reckoned in grains. By this means fractional numbers are avoided, and no ambiguity can arise, as there are no other grains than troy grains. Dr. Kelly, in his *Universal Cambist*, an elaborate and useful work, states that the dram avoirdupois, like the drachm of the apothecaries, has sometimes been divided into 3 scruples and 60 grains; but as no such weight as an avoirdupois grain ever existed, the use of the expression is an instance of the confusion inseparable from having different systems of weights, in which the same names are applied to things totally distinct.

The standards in the Exchequer are: those of weight; 16 avoirdupois weights, ranging from 56 lbs. to $\frac{1}{2}$ dram; 15 troy weights, under 5 Geo. IV. c. 74, from 1 lb. to 1 grain; 30 bullion troy weights, under 16 Vict. c. 29, from 500 oz. to ·001 oz.; those from ·001 oz. to ·005 oz. being of platinum wire, the others of brass, electro-gilt; a yard made of gun metal; ten measures of capacity, from the bushel to the half-gill; and two gas standards, one of weight, i.e. 62,321 lbs., the weight of a cubic foot of distilled water at 62° Fahrenheit; a cubic foot bottle; a 10-feet, 5-feet, and 1-foot gasholder. For a full account of the various proceedings for fixing and verifying the British standards, see Mr. Chisholm's *Report on the Exchequer Standards of Weight and Measure.*

Tables of British Weights.

1. *Imperial Troy Weight.*—Standard: One cubic inch of distilled water, at 62° Fahrenheit's thermometer, the barometer being 30 inches, weighs 252·458 troy grains.

grs.	dwts.	oz.	lb.
24 =	1	—	—
480 =	20 =	1	—
5760 =	240 =	12 =	1

Troy weight is used in weighing gold, silver, jewels, &c., and in philosophical experiments.

2. *Apothecaries' Weight.*—Standard: The same as in troy weight, with the ounce divided into 8 drachms and 24 scruples.

grs.	scrs. (℈)	drs. (ʒ)	oz. (℥)	lb. (℔)
20 =	1	—	—	—
60 =	3 =	1	—	—
480 =	24 =	8 =	1	—
5760 =	288 =	96 =	12 =	1

Medicines are compounded by this weight; but drugs are usually bought and sold by avoirdupois weight.

3. *Imperial Avoirdupois Weight.*—Standard: The same as in troy weight; and one avoirdupois pound = 7,000 troy grains.

drs.	oz.	lbs.	qrs.	cwts.	ton.
16 =	1	—	—	—	—
256 =	16 =	1	—	—	—
7,168 =	448 =	28 =	1	—	—
28,672 =	1,792 =	112 =	4 =	1	—
573,440 =	35,840 =	2,240 =	80 =	20 =	1

This weight is used for the general purposes of commerce.

The preceding are the British statute weights; but numerous other discordant denominations of weight, generally multiples of the avoirdupois pound, are still used in different parts of the country for weighing particular kinds of merchandise. One of the most common of these is the *stone*, which has a great variety of different significations. In London, however, only two stones are generally understood; viz. the stone of 8 pounds for butchers' meat, and the stone of 14 pounds for other commodities. (For values of different local weights, see Buchanan's *Tables of Weights and Measures*; General Paisley's work *On the Measures, Weights, and Money used in this Country*; M'Culloch's *Com. Dict.*; Kelly's *Universal Cambist*, &c.)

A particular denomination of weight, a *carat*, is used for weighing diamonds. An ounce troy is equivalent to $151\frac{1}{2}$ carats; whence a carat is nearly equal to $3\frac{1}{6}$ grains. In expressing the fineness of gold by *carats*, the term rather denotes a proportion than a weight. Thus gold 22 carats fine signifies an alloy such that the proportion of the weight of pure gold to that of the whole weight is as 22 to 24; or such that it contains 22 parts by weight of pure gold, and 2 parts of some inferior metal.

For the French system of weights, see Metric System.

Weight. In Mechanics, this term sometimes denotes the resistance to be overcome by a machine, whether in raising, or sustaining, or moving a heavy body. The force applied to the machine for this purpose is called the *moving power*; and when equilibrium subsists, the ratio of the weight to the moving power is termed the *mechanical advantage* of the machine. In all cases of equilibrium by the intervention of machinery, if the machine be put in motion by a small additional force, the space passed over by the moving power will be greater than that passed over by the weight, in proportion as the weight is greater than the moving power; or the product of the weight by its velocity will be equal to the product of the moving power by its velocity. [Momentum; Virtual Velocity.]

Weight (A.-Sax. wight). In Physics, that property of bodies in virtue of which they tend towards the centre of the earth. In this sense, *weight* is synonymous with *gravity*. [Gravity.]

Weight of Observations. [Probable Error.]

Weights and Scales. The use of these conveniences is very ancient, their earliest

employment being that of measuring money. Weights and scales were the instruments of the money changer in Greece and Rome. In Latin, to pay money is to weigh it; and in point of fact, all weights have been derived originally from the practice of weighing specie. The Sicilian pound, which has been adopted in all countries which have accepted the Roman system, and the German mark, which has prevailed in those which have been influenced by another system, are fundamental in all European weights, and have both been originally quantities of silver. Our own system of weights, while it accepted the pound, attempted to give precision to smaller quantities of money by referring them to a standard derived from the weight of sound average grains of corn. As payments by tale have superseded those by weight, the true origin of all weights has been overlooked.

The earliest scales were no doubt equal balances, the use of the steelyard (the auncel weight of our forefathers) being late both in the ancient and the modern world. But scales were possessed by all persons who were in the receipt of money, and formed a regular and necessary part of the establishment of all persons of any substance. There cannot, we think, be any doubt that at least to the time of Elizabeth payments were invariably made by weight. Statutes defining the standard, and insisting on uniformity in weights, were perpetually enacted, and the police of the old manorial courts [MANOR] was very effective in preserving the justness of weights used. The whole metrical system of England was derived from money weights. [MEASURES.]

The business of testing weights originally lay with the coroner (occasionally the justices in eyre), unless, as was frequently the case, it was reserved by special charter to local magistrates. At present the inspection of weights and the prosecution of offenders is in the hands of the local police of each town or district.

For ancient weights, see Hussey's *Essay*; for modern weights, Tate's *Modern Cambist*.

Weir. [WEAR.]

Weissigite. A mineral which occurs in the trap-rocks of Saxony and Scotland; in the latter country it is associated with zeolitic minerals, in the form of brick-red pseudomorphous crystals, at Calton Hill, Edinburgh, and massive and pseudomorphous near Old Kilpatrick in Dumbartonshire. The Scotch variety seems to be soda-felspar, or Albite; and the Saxon potash-felspar, or Orthoclase.

Weld. The *Reseda Luteola*, a plant cultivated for the use of the dyers. When the seeds are ripe, the plant is cut and dried. It yields a brownish yellow decoction, the colour of which is rendered paler by acids, and richer and deeper by alkalies. Alum throws down a yellow precipitate, and leaves the clear liquor of a fine lemon yellow; tartar also brightens its colour, and solutions of tin give it a dilute green tint. When a mixture of whiting and alum is added to a hot decoction of weld, a yellow precipitate is obtained, which, when collected, washed, and dried, is of a fine delicate colour, and much employed by paper-stainers. Weld is the *gaude* or *vaude* of the French dyers. Its peculiar colouring principle has been called *Luteoline*.

Welding. Some few metals are susceptible of being united by pressure or hammering, or of being *welded* together. Two pieces of potassium may be welded at common temperatures (from 60° to 80°); but the term is generally applied to the junction of two pieces of iron at a white heat, or of iron and steel. Platinum, also, may be welded at a white heat; and it is in this way that that valuable metal, when in the granular or pulverulent state, is worked into bars.

Well (A.-Sax.). In Architecture and Engineering, a deep pit sunk in the ground for collecting and retaining water, and built round with stone, brickwork, or other suitable material, to prevent the earth from falling in. Sometimes wells, after being excavated and built round, are filled in solid with masonry, so as to constitute great pillars or piles for important works to rest upon, and thus insure a good foundation. Such wells are very widely used in India; and part of St. Paul's Cathedral rests upon wells, where the ground was of doubtful solidity.

Before a well is dug, it should first be determined whether a mere reservoir be desired for the water which oozes out of the surface soil, or whether a perpetual spring is needed. If the former be the object in view, a depth of fifteen or twenty feet may probably suffice, though this cannot be expected to afford a constant supply for any large quantity of water, unless a watery vein or spring is hit on; in the latter case, 300 and 500 feet have in some instances been cut through before a permanent supply of water was found. Artesian wells are sometimes carried to a depth of nearly 2,000 feet. [ARTESIAN WELL.]

The art of well-digging is generally carried on by persons who devote themselves exclusively to this work. The site being fixed on, the ground-plan is a circle, generally of not more than six or eight feet in diameter; the digger then works down by means of a small short-handled spade, and a small implement of the pick-axe kind, the earthy materials being drawn up in buckets by the hand or a windlass fixed over the opening for the purpose.

There are two methods of building the stone or brick within the well, which is called the *steining*. In one of these a circular ring is formed, of the same diameter as the intended well, the timber of which it is composed being of the size of the brick-courses with which the well is to be lined. The lower edge of this circle is made sharp, and is shod with iron, so that it has a tendency to cut into the ground; this circular kerb is placed flat upon the ground, and the bricks are built upon it to a

considerable height, like a circular wall. The well-digger gets within this circle, and digs away the earth at the bottom; the weight of the wall then forces the kerb and the brick-work with which it is loaded to descend into the earth, and as fast as the earth is removed it sinks deeper, the circular brick wall being increased or raised at top as fast as it sinks down. Sometimes heavy temporary weights are placed on the top of the wall to force it into the ground; but when it gets very deep it will sink no longer, particularly if it passes through soft strata. In this case a second kerb of a smaller size is sometimes begun within the first. When a kerb will not sink from the softness of the strata, or when it is required to stop out water, the bricks or stones must be laid one by one at the bottom of the work, taking care that the work is not left unsupported in such a manner as to let the bricks fall as they are laid. The latter method is the one now generally pursued, except under peculiar circumstances. The steining is usually executed partly in dry and partly in cemented work laid in rings occurring in intervals of from five to fifteen feet; but sometimes it is necessary to execute the whole work in cement.

The steining of wells is sometimes formed of wrought or cast iron cylinders in about five-feet lengths joined by internal flanges, and guided, when being let down, by four battens fixed to the inside of the well. Sometimes the land-springs are shut out by such cylinders while the rest of the steining is formed in brick-work, and sometimes by 9-inch brickwork set in cement and puddled behind. The thickness proper for the brick steining varies with the nature of the soil and the diameter of the well. Large wells, or wells in soft soils, should have 9-inch steining in two separate 4½-inch rings laid in cement; but for small wells, or firm soils, one 4½-inch ring laid in cement will suffice, but the bricks should be hard and well burnt.

Well-diggers sometimes experience great difficulty from a noxious air which fills the well and suffocates them if they breathe it. The usual mode of clearing wells of such air, is by means of a large pair of bellows, and a long leathern pipe, which is hung down into the well to the bottom, and fresh air forced down by working the bellows.

To find the position of springs, when not deeply seated, the following indications will suffice: In the early part of the year, if the grass in any one spot assumes a lighter green than in others, or if in summer the gnats hover over a particular spot, or if in early morning more dense vapours rise from one spot than from others, water will be found beneath. Deeply seated springs can be discovered only by a careful examination of the geological formation. But the general rule will be found to hold good, that the subterranean waters flow in the same direction as the surface waters, though this rule is sometimes violated by accidental faults and dislocations in the strata. Springs are not often met with at the heads of valleys, but rather at the intersections of the subsidiary valleys with the principal one.

WELL. A small enclosed space near the mainmast, extending from the bottom of the ship to the principal gun deck, containing the pumps. It is fed by the limbers.

Wellingtonia. A fine coniferous tree from the mountains of California, supposed at one time to be distinct from SEQUOIA, to which it is now generally united.

Welwitschia (after Dr. Welwitsch, a German botanist). This is perhaps the most remarkable of all known plants. It comes from tropical Africa, where, along with other plants, it is called *Tumboa* by the natives. Dr. Hooker regards it as forming a genus of *Gnetaceæ*. In its youth its two original cotyledonary leaves appear to grow considerably, and extend horizontally in opposite directions, raised but little above the surface of the sand, whilst the intervening stock thickens and hardens, assuming an obconical shape, flat at the top, and rapidly tapering below into the descending root. As years go on, the original pair of leaves, having attained their full size and a hard tough fibrous consistence, do not die away, but gradually split up into shreds; the woody mass which bears them rises very little higher, but increases horizontally both above and below the insertion of the leaves, so as to clasp their base in a deep marginal slit or cavity; and from the upper side at the base of the leaf, several short flowering stalks are annually developed. These are erect, dichotomously branched jointed stems, rising from six inches to a foot in height, and bearing a pair of small opposite scales at each fork or joint, each branch being terminated by an oblong cone, under the scales of which are the flowers and seeds. The result is, that the country is studded with these misshapen table-like or anvil-like masses of wood, whose flat tops, pitted with the scars of old flowering-stems, never rise above a foot from the ground, but vary according to age in a horizontal diameter of from a few inches to five or six feet—those of about eighteen inches diameter being supposed to be already above a hundred years old.

Dr. Welwitsch found these misshapen monsters, deeply sunk in the soil with their middle sized roots, in considerable quantities at Cabro Negro (15° 40′ south lat.), on the dry plateau of the coast of Benguela, which is covered with loose sandy rough rubble, and is from 300 to 400 feet above the level of the sea. A little north of this place, at Mossamedes, in the neighbourhood of the Nicolas river, on the little Fishbay (at 14° 20′ south lat.), Herr Monteiro found it at a later period in a perfectly similar situation on quartzose schistose soil; and by Mr. Baines and Mr. Anderson it was seen in Damara-land, between 22° and 23° south latitude, in the neighbourhood of Whalefish Bay, in a district in which not a drop of rain ever falls. The distribution of this remarkable plant falls apparently between 14° and 23° south latitude. The -wn,

when divested of its leaves, resembles so closely the cracked surface of an old *Polyporus igniarius*, that it might, on a superficial view, be taken for a fungus.

In the *Transactions of the Linnean Society*, vol. xxiv., may be found a beautiful series of drawings of this remarkable plant.

Wen (A.-Sax. wenn). A term commonly applied to fleshy and other tumours, more especially when they affect the face or neck.

Wendish Language. A name given to the dialect belonging to the Wendic class of the Aryan family of languages spoken in Lusatia. The people who use it probably do not exceed 150,000 in number.

Werewolves. The first part of this word is the same as the *were* (Lat. vir, *a man*) in wergild. The phenomena and history of werewolves or lycanthropes have been examined by Mr. S. B. Gould in his *Book of Were-wolves*. Whether the idea may not be traced back to phrases of which the original meaning had been forgotten, is perhaps worth consideration. [Lycanthropy; Lycaon; Rishis, the Seven.]

Wergild (A.-Sax. from wer; Lat. vir, *a man*, and gild, Ger. geld, *gold*). Among the Anglo-Saxons, the compensation paid by a delinquent to the party injured, or his relations, for offences against the person. This custom was common to all the Teutonic tribes, and to many Celtic. It is mentioned by Tacitus in his account of the ancient Germans. The great distinction between Saxon freemen was that between the *eorls*, or nobility, and *ceorls*, or commonalty; and the *were* of the former was usually rated at six times the amount of that of the latter. [Thane.]

Wernerite. A name given to the mineral Scapolite, after Werner, the German mineralogist. It is a silicate of alumina, lime, and oxide of iron, found in Norway and Sweden, and also in Switzerland.

Wesleyans. [Methodists.]

Western Empire. The name given by historians to the western division of the Roman empire, when divided, by the will of Theodosius the Great, between his sons Honorius and Arcadius, A.D. 395. (Gibbon, *Roman Empire*; Milman, *Latin Christianity*; Bryce, *Holy Roman Empire*.)

Whale. [Balæna.]

Whale Fishery. In early times the whale was frequently found on the shores of this country, sometimes in large shoals, and was hunted partly for its oil, partly for the sake of food, whale meat, *balæna* or *baleine*, being frequently mentioned in ancient accounts as an article of purchase and sale. Greater refinement, and especially the progress of agriculture, which has enabled the community to supply itself with fresh meat *all the year through*, have superseded the use of whale as an article of food; and, for the last two centuries or more, this animal has been hunted only for its oil and a few other of its products, especially the laminated and fringed cartilages, which form a strainer for holding the minute insects on which the northern whale feeds.

The developement and sustentation of the whale fishery was for a long period a subject of great anxiety to the British parliament. It was believed to be an important source of wealth, and with greater reason it was imagined, that the fishery afforded an excellent school for rearing hardy seamen, available for the public service. To further the whale fishery, it was provided by law that bounties should be given to any ship, proportioned to its tonnage, which was engaged in this pursuit. In 75 years, between 1750 and 1820, the bounties paid to this industry amounted to 2,500,000*l.*, the average annual value of the produce being favourably estimated at 100,000*l.* It is easy to see that, even if the labour and capital employed in the fishery were taken to be worth nothing, the country lost a round annual sum by the process. In short, the industry was wholly factitious and absolutely unprofitable.

The delusion which occupied the minds of those who legislated for the support of the whale fishery was in great degree sustained by the notion, that all which can be got from the sea is gain; and the fact that, in such a case, the community is sufficiently alive to the contingency of such absolute profits without the aid of a bounty, was never recognised.

The whale fishery was twofold: that of the northern seas, in which the common whale was hunted; that of the southern, in which the chief object of pursuit was the spermaceti whale. The produce of both these animals, before chemistry had supplied the public with substitutes for train oil and spermaceti, was of far greater economical importance than it is now. But as the materials for artificial light and for the lubrication of machinery are now supplied from many other sources, it is probable that the fishery will be almost superseded as a regular branch of industry. In such a case whales will again become plentiful, just as the beaver, since the use of its fur as a material for hats has almost ceased, is becoming plentiful in places where it had been almost exterminated. For further details on the whale fishery, the reader is referred to the *Commercial Dictionary*.

Wheat (so called as being the white plant—Goth. hvaiteis; A.-Sax. hvæte; Lith. kwetys; all these words pointing to the Sansc. sveta, *white*: Max Müller, *Lectures on Language*, second series, ii.). The name of a well-known Cereal Grass, belonging to the genus *Triticum*, the cultivated forms of which have been produced, it is thought, by progressive developement from certain forms of *Ægilops*. [Triticum.]

Wheat is by far the most important and most extensively cultivated species of bread-corn raised in England. It is sown after fallow, turnips, cabbages, potatoes, beans, clover, and grasses, &c.; but it never, at least in the best farmed districts, follows any other white crop. Wheat may be raised on all sorts of

soils; but those of a clayey nature are the most suitable. So peculiarly, indeed, is wheat adapted to heavy stiff lands, that they are usually termed *wheat soils*. The lighter the soil, the less is it suited to this species of grain; and it is an error in practice to force the cultivation of wheat on soils, and under circumstances, better suited to the production of other grain. In this country it does not admit of being raised at a great elevation. As it is a crop on which the farmer mainly depends, the preparation for it, in whatever rotation it comes, should be an object of great care and attention. If it be intended to sow wheat after fallow, the land is repeatedly ploughed, harrowed, and well manured; if after clover, only one ploughing is given, and seldom more after beans; where tares have been previously sown, they are got off the land in sufficient time to plough it more than once; when wheat follows turnips or cabbages, it must, unless they be stored or eaten before winter, be sown in the spring months.

The varieties of Wheat are perpetually changing, in consequence of variations of culture, climate, and soil, those most in use being distinguished by different local terms. They may be divided into the two great classes of *red* and *white*—the latter being superior as respects quality of produce, and the former as respects productiveness and hardiness.

Winter wheat is seldom sown in any part of England before the beginning or middle of September, or later than the end of November. Spring wheat is generally sown between the middle of February and the middle of April. The seed is often pickled or steeped; a process intended to prevent *smut*. The quantity of seed allowed to an acre usually varies from 1 to 2½ bushels.

Wheat harvest generally begins in the south of England, early in August; in the midland counties it is about ten days, and in the northern counties from a fortnight to three weeks later. In the southern counties wheat is generally ready in a week or ten days after cutting; whereas in the north it is necessary to let it stand out for two or three weeks. In the southern, eastern, and midland counties, it is frequently put into barns: in the north, it is almost universally stacked.

As this grain is so extensively cultivated, frequently on very inferior soils, and after very imperfect preparation, the produce per acre varies materially in different counties and districts. It is also very liable to injury from bad seed time, a wet winter, or a blight during the period of its flowering (which last is the most common cause of the failure or deficiency of our wheat crops); so that its produce varies as much in different seasons on the same farms, and under the same management, as it does during the same season on different farms. The lowest quantity of produce, except where an absolute deficiency from blight occurs, may, perhaps, be rated at from 10 to 12 bushels an acre, and the highest at from 48 to 56 or 64 bushels. Occasionally, indeed, even more than this has been reaped on deep loams, and in some of the more favoured and highly cultivated parts of Kent, Essex, Lincoln, Somerset, &c.

The southern counties are the most distinguished for the quality as well as the quantity of their wheat. In the north, this grain is sometimes raised of a very fine quality; but generally it is inferior, being colder to the feel, darker coloured, thicker skinned, and yielding less flour. In the best wheat counties, and in good years, the weight of an imperial bushel of wheat varies from 62 to 64 lbs. Where the climate is naturally colder, wetter, and more backward, or in bad seasons, the weight of the bushel does not exceed 58 lbs. The weight of the straw is about double that of the grain; so that an acre yielding 30 bushels of wheat, at 60 lbs. per imperial bushel, would yield 3,600 lbs. of straw.

The geographical range over which wheat can be grown is peculiar. It is not produced in tropical climates. Here its place is taken by rice. There is a northern limit to its growth, beyond which oats can be cultivated. Here, however, wheat is not seen, only because there is not sufficient heat to ripen it. It is, on the whole, the hardiest of the cereals, and it is said that its quality is always best when it grows on that margin beyond which it will not ripen at all. In the same manner the vine has a wide geographical range, will grow luxuriantly where its fruit cannot come to maturity, will stand severe cold in winter, and produces better wine in such regions as approach its highest geographical limit.

Wheat is the most costly of the cereals. The seed sown on any given area is not more than half the amount which can be sown of other kinds of corn. The crop is scantier, and more exhausting to the soil. It sends its principal roots deeply into the earth. Hence it thrives well on strong and stiff ground, and can bear drought better than any other kind of grain. The whole, or nearly the whole, nutriment contained in the plant is lodged in the seed. Wheat straw, as fodder, is worth less than the straw of other grain, though it is very valuable for certain economical uses.

The meal or flour of wheat is better adapted to sustain the various vital functions than that of any other kind of grain. For many reasons, the employment of wheat as an article of food produces special economical effects on the community with which its use is customary. From the very earliest times wheat has been the common food of the people in this country. Rye, the closest analogue to wheat, has never been widely used in England; and barley, oats, and the leguminous plants have never been the staple food of any large section of the English nation. Five hundred years ago the English peasant ate wheaten bread, brewed his beer from barley malt, and gave oats to the horses. Fortunately he has never condescended to live on the meaner kinds of corn, and he owes much

his physical and economical position to this ıbit of life.

Up to the middle of the eighteenth century heat was grown in England in excess of the ants of the population. It is probable that ıe inhabitants of England and Wales did not ıen exceed 7,500,000. Since that time, howrer, the home growth of wheat has seldom ɜen sufficient for the wants of the increasing ɔpulation. Of course, with this increase, the ecessity of importing wheat increases also. he fact that there was an excess of production ɔncurrently with a growth of population, is to e explained by the great improvements in griculture which were effected in the country etween the Restoration and the accession of ɫeorge III. It was during this time that the ystem of turnip farming was established, and rtificial grasses were introduced.

At the present time, from one-third to oneɔurth of the wheat consumed in Great Britain nd Ireland is imported from foreign regions. ʼill within the last ten years, the chief supply f foreign wheat was shipped at the two ports, ɔantzic on the Baltic and Odessa on the ɜlack Sea. Latterly, however, vast quantities ıave been imported from the Western States of he American Union, the principal entrepôt f American grain being Chicago, which in the ourse of a few years has grown from a small nd unimportant village to a vast city. It eems reasonable to conclude that, as large tracts f prairie land are broken up and brought into ultivation, and as the great valleys of Upper ɔanada are brought within the influence of the orn trade, the supply of wheat will be even nore abundant, and suffice for the sustenance f the various populations of those parts of he Old World, in which trade and manufactures ıre flourishing.

ıccount of the Quantities of Foreign and Colonial Wheat imported into the United Kingdom, in each Year from 1850 *to* 1864 *inclusive, with the Annual Average Prices of Wheat per Imperial Quarter.*

Years	Imported	Annual Average Prices of Wheat per Imperial Quarter	
	Qrs.	s.	d.
1850	3,738,995	40	3
1851	3,812,008	38	6
1852	3,060,268	40	9
1853	4,915,430	53	3
1854	3,431,227	72	5
1855	2,667,702	74	8
1856	4,072,833	69	2
1857	3,437,957	56	4
1858	4,241,719	44	2
1859	4,000,922	43	9
1860	5,880,958	53	3
1861	6,912,815	55	4
1862	9,469,270	55	5
1863	7,489,000	50	4
1864	7,137,450	48	0

The proportionate money value of the three principal kinds of grain, wheat, barley, and oats, varies little even if remote periods are contrasted. Thus for the 140 years between 1261 and 1400, the proportion of barley to wheat (taken at 100) is 73·14, of oats 42·05. In our own time, or till lately, barley has been somewhat cheaper, perhaps by the operation of the malt duty, and other charges levied on grain and for distillation; oats are a little dearer, owing, probably, to the great increase in the number of horses kept for draught. Taking the same proportion, and estimating an average from the ten years ending 1865, wheat being as before at 100, barley will be 70, oats 45·95. Nor is there any doubt that if any similar decade of years were taken, the proportion would follow the same or nearly the same rates.

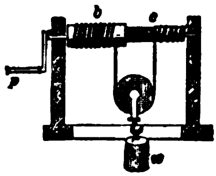
It must be borne in mind, that, in addition to the importation of wheat as grain, large quantities are annually imported as flour. Virtually the whole of the importation is retained for home consumption.

Wheel (A.-Sax. hweol). In a Ship, the wheel and axle by which the tiller is moved.

Wheel Animal or **Wheel Animalcule.** [ROTIFERS.]

Wheel and Axle. In Mechanics, one of the simple mechanical powers or machines, consisting of a wheel having a cylindrical axis passing through its centre, resting on pivots at its extremities, or supported in gudgeons, and capable of revolving. The power is applied to the circumference of the wheel, and the weight or force to be overcome to the circumference of the axle; equilibrium takes place when the power and weight are to each other inversely as the radii of the circles to which they are applied.

A form of the wheel and axle, called the *differential windlass*, is represented in the subjoined figure. The axle consists of two parts having different thicknesses; and the rope after being coiled round one of the parts is carried round a pulley attached to the weight, and coiled round the other in the opposite direction.



The power p is applied at the handle of the winch, which here takes the place of the wheel. In order to compute the advantage gained by this machine, let p denote the circumference described by the handle of the winch, b the circumference of the thicker part of the axle, and c that of the thinner part; then, while the winch makes one revolution in the direction which raises the weight, the part of the rope which passes from the one part of the axle to the other round the pulley will be shortened by the quantity $b-c$, and consequently the weight w will be raised through the height $\frac{1}{2}(b-c)$. But the space described in the same time by the power p is equal to that through which the

handle of the winch passes, or equal to a; therefore, by the principle of virtual velocities, $p : w :: \frac{1}{2} (b-c) : a$, or $p\,a = \frac{1}{2}\,w\,(b-c)$. As the circumferences of circles are to their radii in a constant ratio, it is evident that the formula will apply equally if the letters a, b, c be taken to represent the respective radii. In other words, the magnitude of the weight raised with any given force applied to the handle will be in the proportion of the slowness with which it is raised; and the more nearly the winding-up and the paying-out parts of the axle approximate in diameter, the slower will be the rate at which the weight is raised. The same principle is embodied in the contrivance termed *Hunter's screw*, and in all differential mechanisms.

Wheel Purchase. A simple contrivance for moving a wheeled carriage with increased power. It is formed by hooking a drag-rope to the tire of a wheel as near the ground as possible, carrying the running end up over the tire, and stretching it out so as to form a tangent to the wheel; when the rope is hauled on, the carriage advances. The power gained is in proportion to the diameter of the wheel.

Wheel Work. In Machinery, wheel work consists of a combination of wheels imparting motion to one another. The motion is communicated from the one wheel to the other, either by teeth cut in their circumferences, or on external surfaces, and working in one another, or by circular V grooves cut in the peripheries of the wheels, with corresponding circular projections for jamming tightly into the grooves—a combination usually known as *frictional gearing*. Pulleys driven by belts, though not commonly known as wheel work, come under the same general laws. In either of these ways the velocities of points in the circumferences of the impelled wheels are equal; and consequently their angular velocities, or the number of revolutions which they make in the same time, are inversely as their radii. When one wheel drives another by teeth, they necessarily turn in opposite directions; if united by a cord or belt, they will turn in the same direction, if the belt does not cross itself between the two wheels; but if the belt crosses itself, they will turn in opposite directions. The chief advantage of transmitting motion by cords or belts is, that the wheels may be placed at any convenient distance from each other, that they may be made to turn either in the same or in opposite directions, and that they may be driven at a higher rate of speed than would be suitable for toothed wheels.

When the resistance of the work is not great, wheels may be made to act on one another so as to communicate motion by the mere friction of their circumferences. In order to increase the friction, the surfaces of the rims are sometimes faced with buff leather, or wood cut against the grain, and pressed together with a certain degree of force. This method is sometimes used in spinning machinery, and has been applied successfully to the saw mill, and also to working cranes or hoists, but is seldom adopted in works on a great scale. Motion communicated in this manner proceeds smoothly and evenly, and is accompanied with little noise.

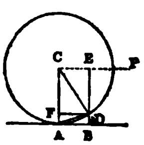
When motion is to be transmitted through a train of wheel work, toothed wheels are generally employed. A small wheel acted on by a large one is called a *pinion*, and the effect produced by any combination of wheel work is easily estimated by looking to the initial and final velocities. The number of revolutions made respectively by any engaged pair of wheels will vary as their circumferences, or, what is the same thing, as their diameters; if the diameter of a wheel, therefore, be ten times greater than that of a pinion engaged with it, then for every revolution made by the wheel, the pinion must make ten, or for every revolution made by the pinion the wheel must make $\frac{1}{10}$ of a revolution. Now, seeing that power is pressure multiplied by space, the less the space through which the axle passes, the greater must be the force with which it turns, and the greater the space the less the force. In winches and cranes, it is consequently easy to estimate the weight which will be raised by any given pressure applied to the handle, for we have only to ascertain the relative velocities of the handle and of the weight, and if the weight moves with only $\frac{1}{1000}$ of the speed of the handle, then the rotatory pressure applied to the handle will counteract 1,000 times the pressure at the other end of the machine, or raise 1,000 times the weight.

Toothed wheels, as distinguished by the position of the teeth relatively to the axis, are of three kinds: *spur wheels*, *crown wheels*, and *bevelled wheels*. When the teeth are raised upon the edge of the wheel, or are perpendicular to the axis, the wheel is a *spur wheel*; when they are raised parallel to the axis, or perpendicular to the plane of the wheel, it is a *crown wheel*; and when they are raised on a surface inclined to the plane of the wheel, it is called a *bevelled wheel*. The combination of a crown wheel with a spur wheel as pinion is used when motion is to be communicated round one axis to another at right angles to it. Two bevelled wheels are employed to transmit motion from one axis to another inclined to it at any proposed angle. Wheels moving in opposite directions with an intermediate wheel between them, which is capable of being carried round on a radial arm, are termed *differential wheels*. If the two wheels are made to perform the same number of revolutions per minute in opposite directions, but if one has a tooth more than the other, then at each revolution the intermediate wheel will be advanced a tooth, carrying the radial arm with it in slow revolution. Sometimes wheels are made elliptical, eccentric, and of other forms, for the purpose of imparting peculiar motions; and in the sun and planet wheels used in old varieties of the steam engine, one wheel was made to revolve round the other.

The proper mode of forming the teeth of wheels is described in a separate article. [TEETH

OF WHEELS.] In large wheels, and where a very smooth motion is necessary, the teeth of wheels are sometimes formed in steps, or the wheel is cut transversely into a number of thin and parallel wheels which are bolted together; but each succeeding wheel is set a little in arrear of the preceding one on the shaft, so that the teeth of the several wheels do not come in the same line with one another, but break bond. This expedient we owe to the ingenuity of Hooke, as we also owe to him the expedient of spiral gearing, by which the same end is attained. Sometimes an endless screw is made to work into teeth on the edge of a wheel, the wheel being thus advanced a tooth for each revolution made by the screw. In mill gearing, the teeth of the wheels are generally made too long, and thus more sliding friction is produced than would be the case if shorter teeth were employed. (Bourne *On the Steam Engine*.)

Wheels of Carriages. Wheels applied to carriages serve a twofold purpose. In the first place, they greatly diminish the friction on the ground by transferring it from the circumference to the nave and axle; and, in the second place, they serve to raise the carriage more easily over obstacles and asperities met with on the roads. The friction would be diminished in the proportion of the circumference of the axle to that of the wheel, even if the wheel could be well lubricated, and hence the larger the wheel, and the smaller the axle, the less is the friction. The mechanical advantage of the wheel in surmounting an obstacle may be computed from the principle of the lever. Let the wheel touch the horizontal line of traction in the point A, and meet a protuberance B D. Suppose the line of draft C P to be parallel to A B, join C D, and draw the perpendiculars D E and D F. We may suppose the power to be applied at E, and the weight at F, and the action is then the same as the bent lever E D F turning round the fulcrum at D. Hence P : W : : F D : D E. But F D : D E : : tan F C D : 1; and tan F C D = tan 2 (D A B); therefore P = W tan 2 (D A B). Now, it is obvious that the angle D A B increases as the radius of the circle diminishes; and therefore the weight W being constant, the power required to overcome an obstacle of a given height is diminished when the diameter is increased. Large wheels are therefore best adapted for surmounting inequalities of the road. There are, however, circumstances which prescribe limits to the height of the wheels of carriages. If the radius A C exceeds the height of that part of the horse to which the traces are attached, the line of traction C P will be inclined to the horizon, and part of the power will be exerted in pressing the wheel against the ground. The best average size of wheels is considered to be about 6 feet in diameter. The fore wheels of carriages and waggons are usually made much smaller than



this, to enable them to swivel beneath the floor of the vehicle.

Wheel-ore. A macled variety of Bournonite found at Herod's-foot Mine in Cornwall, and at Kapnik in Transylvania.

Whelps. Short upright pieces placed round the barrel of the capstan, to afford resting points for the messenger or hawsers.

Wherry (another form of FERRY). A boat with bow and stern nearly alike, and both making a very large angle with the keel.

Whetstone. A talcy slate containing silica, used for hones. [NOVACULITE.]

Whewellite. A native oxalate of lime from Hungary; named after Dr. Whewell, late master of Trinity College, Cambridge.

Whey (A.-Sax. hwæg). The limpid part of milk which remains after the separation of the curd and butter. It consists chiefly of water holding between three and four per cent. of sugar of milk in solution. [MILK.]

Whigs. The well-known designation of a political party in English history. It was first used in the reign of Charles II., the term being afterwards assumed as a party name by that body of politicians who were most active in placing William III. on the throne of England. Since that time it has been borne by successive generations of those who have followed in the same political line. Generally speaking, the principles of the Whigs have been popular, and their measures have tended to increase the democratic influence in the constitution. Defoe (*Memoirs of the Church of Scotland*, 1717, p. 173), speaking of the Covenanters, thus accounts for the origin of the name: 'This is the first time that the name of a Whigg was used in the world—I mean as applied to a man or to a party of men; and these were the original primitive Whiggs, the name for many years being given to no other people. The word is said to be taken from a mixed drink the poor men drank in their wanderings, composed of water and sour milk.' But Bishop Burnet, who lived nearer to the time in which the nickname was invented, gives the following explanation (*History of his Own Times*): 'The south-west counties of Scotland have seldom corn enough to serve them round the year, and the northern parts producing more than they need, those in the west come in the summer to buy at Leith the stores that come from the north; and from a word *whiggam*, used in driving their horses, all that drove were called Whiggamores, and, shorter, the Whiggs. Now, in that year, after the news came down of Duke Hamilton's defeat, the ministers animated their people to rise and march to Edinburgh, and they came up marching on the head of their parishes with an unheard-of fury, praying and preaching all the way as they came. The marquis of Argyle and his party came and headed them, they being about six thousand. This was called the Whiggamores' inroad, and ever after that all that opposed the court came, in contempt, to be called Whiggs; and from Scotland the word

was brought into England, where it is now one of our unhappy terms of distinction.'

Whin. [ULEX.]

Whinstone. A species of basaltic rock, or greenstone, forming hard dykes penetrating other rocks. The name is also sometimes locally applied to bedded rock of the same nature.

Whirlpool. A vortex, eddy, or gulf, where the water has a circular motion. Whirlpools are produced by the meeting of currents which run in different directions. Their danger to navigation is well known, but is perhaps not equal to the dread which sailors entertain of them. Some of the most celebrated are the Euripus, near the coast of Negropont; the Charybdis, in the straits of Sicily; and the Maelstrom, on the northern coast of Norway. The latter is now known to be of a very harmless character. (Murray's *Geography*, Introd.)

Whirlwind. A revolving column or mass of air, supposed with most probability to be produced by the meeting of two currents of air blowing in opposite directions. It is analogous to the *whirlpool*. When the opposite currents have the same velocity, the circulation will be maintained at the same spot; but if the motion of one of them is more rapid than that of the other, it will transport the whirling motion with its excess of celerity, and a progressive and rotatory motion are thus maintained at the same time. Whirlwinds generally occur in summer, and are most violent in tropical countries, where they frequently produce most destructive effects. The diminution of atmospheric pressure arising from the centrifugal force of the revolving column is thus computed by Professor Leslie: 'If r denote in feet the radius of the extreme circle described by the whirlwind, and t the time of circumvolution in seconds, the elasticity, or pressure of the column at the verge, will suffer a diminution corresponding to the fraction $\frac{5r}{4t^2}$. The amount of this diminution over the whole base would be reduced to three-fourths; and, consequently, h expressing the height of the revolving column of air, $\frac{15rh}{16t^2}$ would represent the mean effect of centrifugal action. Suppose the whirlwind to have an elevation of 200 feet, and a radius of 50, and to circulate in 3 seconds, the diminished pressure would be equal to the weight of a column of $\frac{15 \times 50 \times 200}{16 \times 9} = 1040$ feet. This example, assuming a celerity of sixty-five miles an hour, might be reckoned an extreme case; but it would occasion the mercury to sink in the barometer more than an inch, or 1·12.' (*Ency. Brit.* art. 'Meteorology.') [STORM; WINDS.]

Whisky (for the origin of the word, see USQUEBAUGH). A species of corn spirit, having the smoky flavour of burnt peat. [DISTILLATION.]

Whispering Domes or Galleries. Places in which whispers or feeble sounds are communicated to a greater distance than under any ordinary circumstances. The dome of St. Paul's church in London furnishes an instance. [SOUND.]

Whist (so called from whist, *be silent*, as requiring close attention). A game at cards, played by four persons, in a double combination, two of them being *partners* against a partnership of the other two. A full pack of fifty-two cards is used, and they rank in their natural order, except that the ace of each suit, instead of being the lowest, is made the highest. The cards are dealt round, thirteen to each player, the last or bottom one, belonging to the dealer, being *turned up* or shown; the suit to which this belongs is called the *trump* suit, and takes precedence of all the others.

The player to the left of the dealer then plays a card, to which the other players in succession must *follow suit*, i.e. play cards of the same suit, if they have them. These four cards constitute a *trick*, which is won by the person who plays the highest card, and is picked up by the winner or his partner. The winner of this then *leads*, or commences, a new trick, and so on till the whole thirteen are played.

When a player cannot follow suit, i.e. has no card of the suit led, he may either play a trump, which wins the trick by the precedence of the suit, or may *discard* a card of some other suit.

The score is made in two ways, by *tricks* and *honours*.

The partners who, together, gain the majority of tricks in the hand, score one for every trick made above six.

The ace, king, queen, and knave of the trump suit, are called *honours*, and score one each for whoever holds them. Thus, if one partnership hold two between them, the other partnership also holding two, they cancel each other, and no one scores. If one partnership hold three honours, and the other one, the former score the difference—two, and are said to count *two by honours*. If all four honours are in the hands of one partnership, they count *four by honours*.

The points thus scored by tricks and honours are called *game points*. In the old-fashioned or *long* whist, ten of these make a game; in the modern or *short* whist, the number has been reduced to five.

Two games, won by the same party, constitute a *rubber*, and the games have different values, depending on the state of the score of the losing party. These details, as well as other laws affecting the conduct of the game, may be found in books on the subject.

Although, as will be seen, the construction of the game is so exceedingly simple that a child may learn it in an hour, yet the option which each player has as to the card he shall play, leaves so much scope for voluntary action as to give whist an exceedingly high character in an intellectual point of view. A good player must, in the first place, be master of a somewhat re-

condite and elaborate *system* of play, which has been deduced by a long series of observations and reasonings as the best to be followed; he must then *observe* and *remember* very carefully the cards played, which furnish the data on which be proceeds; from these data he must next draw rapid *inferences*, as to the distribution in the various hands of the cards yet unseen; and finally he must act on the whole of the information thus gained, with judgment and skill, for which there is the widest possible scope. To do all this well requires not only very high mental and intellectual power, but considerable study and long practice. Hence this fine game has always commanded the attention of men of the first order of mind.

The origin of whist is somewhat obscure; but it has existed in its present form a long time. Hoyle appears to have been the first to perceive, a century and a quarter ago, that it was capable of being reduced to a scientific and logical system of high intellectual merit; and though his descriptions were somewhat obscure, they served to establish a well-marked school of play.

This has been adopted in its general form by all succeeding writers and players of eminence, whose experience and thought have gradually developed the system into a more complete and perfect form, and have added to it modern improvements of much interest and value, tending still further to raise the intellectual character of the game.

There are many books published which contain directions for the practice of whist-playing; but the clearest exposition of the theory on which the modern scientific system of play is based, will be found in an essay forming the second part of the sixteenth and following editions of *Short Whist*, by Major A.

It is shown in this essay that the basis of the true theory of the game lies in *combining* the hands of the two partners. It forbids the player to consider his own hand apart from that of his partner, but enjoins him to treat both in strict conjunction; teaching him, in fact, to play the *two hands combined*, as if they were one.

It is impossible here to explain this system more fully; but we may add a summary of the more important rules which characterise the modern scientific game.

1. Your first lead should *inform* your partner what is the most important component of your hand. Therefore it should be from your *best long suit*.

2. In this suit, having ace and king, lead king, then ace.

Having king and queen, lead king.

Having ace, queen, knave, lead ace, then queen.

Having ace and four small ones, lead ace, then smallest.

Having queen, knave, then lead queen.

In most other cases lead the lowest.

3. Lead your own suit before you return your partner's, unless he leads trumps, which return immediately.

4. In returning your partner's lead, if you hold not more than three cards of the suit originally, return the highest; if more, the lowest.

5. But, in any position, if you hold the master card, play it the second round.

6. When at a loss for a lead, lead up to the weak hand, or through the strong one.

7. Second hand, generally play your lowest, unless you hold ace and king, or king and queen, when put the lowest of them on.

8. Holding five or more trumps, always lead them the first opportunity, or signal to your partner to do so.

9. Look out for your partner's signal for trumps, to which, holding not more than three, lead out your highest; if more than three, your lowest.

10. Do not lead through an honour turned up, unless you otherwise wish trumps led.

11. Do not trump a doubtful trick second hand if you hold more than three trumps; with three or less, trump fearlessly.

12. Do not force your partner if you hold less than four trumps yourself.

13. But force a strong adverse trump-hand whenever you can.

14. Always play the lowest of a sequence, if not leading.

15. Discard from weak suits, not from strong ones.

White (A.-Sax. hwit, Ger. weiss, perhaps akin to Lat. videre, visus [WHEAT]). In Painting, a negative colour (if such definition may be allowed); the opposite is *black*, black being void of all colour, properly so called. White objects are assumed to reflect all the light that falls upon them, and black objects are supposed to absorb it all; coloured objects are such as partially absorb and partially reflect light.

WHITE. The colour produced by the combination of the complementary colours, yellow and blue, or crimson and green; and also, by all the prismatic colours mixed in the same proportions as they exist in the solar rays. This is proved both by decomposing white light by means of a prism, and by recompounding the primitive colours in due proportions. [COLOUR; LIGHT; REFRACTION.]

White Antimony-ore. Native oxide of antimony. [VALENTINITE.]

White Arsenic. Oxide of arsenic, or arsenious acid.

White Bait. The name of a small and peculiar species of *Clupea*; confounded, until studied by Mr. Yarrell, with the young of the shad (*Clupea alosa*). The young fish of the white bait (*Clupea alba*, Yarrell) ascend the Thames at the beginning of April, and continue in that part of the river where there is a mixture of salt with fresh water until September, when young fish of the year four or five inches long are not uncommon, though accompanied by others of smaller size; but the parent fish are believed not to ascend beyond

the estuary. The young of the shad are not two inches and a half long till November, when the white bait season is over; and they are distinguished by a spotted appearance behind the edge of the upper part of the operculum, which the white bait never exhibits.

White Caps. A name employed sometimes to indicate *Agaricus arvensis*, which is more commonly known as the Horse Mushroom.

White Cobalt-ore. Native arsenide of cobalt. [SMALTINE.]

White Copper. An alloy used by the Chinese, and called by them Packfong or Pakfong: it is composed, according to Dr. Fife, of 40·4 parts of copper, 25·4 of zinc, 31·6 of nickel, and 2·6 of iron. *German silver* is a modification of this alloy.

White Copper-ore. Native arsenide of copper. [DOMEYKITE.]

White Eagle, Order of the. An order of knighthood in Poland, instituted by Vladislas V. in 1325, and revived by Frederic Augustus I. in 1705.

White Flux. A metalluric reagent, chiefly composed of carbonate of potash.

White Fog. [HOLCUS.]

White Gunpowder. White gunpowder is made by powdering separately equal weights of chlorate of potash, white sugar, and ferrocyanide of potassium, and mixing them cautiously, as it may explode by percussion. It ignites if a drop of sulphuric acid, or a red-hot body, be brought into contact with it. Its explosive power is greater than that of ordinary gunpowder; but it is not available for guns, on account of the rapidity and violence of its combustion.

White Lead. Basic carbonate of lead. This important compound, of which from 17,000 to 20,000 tons are annually manufactured in England, is used chiefly as the basis of white oil paint: it is also employed, to a small extent, in the manufacture of cements. It is chiefly made in two ways: either by precipitation, as when carbonic acid or a carbonate is used to decompose a soluble salt, or a basic salt of lead; or by exposing plates of cast lead to the joint action of the vapour of acetic acid, air, and carbonic acid: it is by the latter process only that the resulting carbonate of lead is obtained of that degree of density and opacity, and perfect freedom from crystalline texture, which fits it for paint. This last, commonly called the *Dutch process*, was introduced into England about the year 1780. White lead is often largely adulterated with sulphate of baryta, which is detected by insolubility in dilute nitric acid, whereas pure white lead is entirely dissolved by it. [LEAD.]

White Lead-ore. Native carbonate of lead. [CERUSITE.]

White Leg. A disease which generally occurs in women soon after delivery, and which has been erroneously supposed to arise from redundancy of milk. It comes on with stiffness and pain of the limb, which afterwards becomes tumid and tense from the effusion of serum. The disease is essentially an inflammation of the femoral vein, followed by complete or partial plugging of the vessel by a coagulum of blood.

White Line. In Printing, a blank line across the page, formerly generally placed after a paragraph, but now used to mark a greater division of the subject there than that which is shown by the paragraph.

White Precipitate. The white powder which falls on adding ammonia to a solution of corrosive sublimate: it is a compound of peroxide and bichloride of mercury with ammonia: it is virulently poisonous, and is chiefly used in ointments and for killing vermin. It has been regarded as an *amido-chloride* of mercury, and represented as $Hg\ NH_2$, $Hg\ Cl$.

White Stone. A lapidary's name for limpid and colourless rock crystal when cut for jewellery.

White Tellurium. The name given to silver-white or slightly yellowish varieties of Sylvanite.

White Vitriol. The old name of sulphate of ZINC.

White Wood. One of the names applied to the timber of *Tilia americana*. It is also occasionally given to that of *Liriodendron tulipiferum*, *Oreodaphne Leucoxylon*, *Nectandra leucantha*, *Tecoma Leucoxylon*, *Tecoma pentaphylla*, *Lagunaria Patersoni*, and *Pittosporum bicolor*.

Whitefieldian Methodists. The name given to the most numerous body of the Methodists after the Wesleyans, so called from Whitefield, whose early connection with the METHODISTS will be found noticed under that term.

Whiting. The name of a species of the Cod tribe (*Merlangus vulgaris*, Cuv.), and the type of a subgenus, distinguished from the true cod by the absence of the barbules at the chin.

WHITING. Chalk, finely levigated by washing, and used for whitewash and distemper-painting, is sold under this name.

Whitlow (Sax.). A painful inflammation, tending to suppuration, at and about the ends of the fingers.

Whitneyite. A native arsenide of copper found on the north shore of Lake Superior, and named after Professor Whitney.

Whitsunday. In the Calendar, the seventh Sunday, or fiftieth day inclusive after Easter. *Whitsuntide* corresponds with *Pentecost*. This Sunday was called in the ancient church *Dominica Alba*, White Sunday; or *Dominica in Albis*, the Sunday in which *white garments were worn*, it having been formerly a custom with those who were baptised on this day to dress in white for the occasion. The term, however, has by some been derived from the Saxon *wlas*, octave, the eighth from Easter.

Whooping Cough. [HOOPING COUGH.]

Whortleberry (A.-Sax. heort-berg). The name of the *Vaccinium* genus, but especially applied in this country to the fruit of *Vaccinium Myrtillus*.

Wichtyne or **Wichtisite.** A mineral composed of silicate of alumina, with the silicates of iron, lime, soda, and magnesia, met with in black masses at Wichtis, in Finland.

Wickliffites. [LOLLARDS.]

Wildgrave (Ger. graf, *count*). A title assumed in the middle ages, like those of Raugrave and Rhingrave, by certain small dynasties of feudal chieftains in the neighbourhood of the Rhine. A branch of the family of Salm now claims this title.

Wilhelmite or **Willemite.** Native anhydrous silicate of zinc, named after Wilhelm I. king of the Netherlands. It is found crystallised, granular, and massive, at Vieille Montagne, near Aix-la-Chapelle. [WILLIAMSITE.]

Will or **Testament.** In Law, the legal declaration of a man's intentions as to what he wills to be performed after his death. In strictness of language, the term *will* is limited to land; *testament*, to personal estate.

Previously to the reign of Henry VIII. there was no general power of devising lands in England, though such a right existed in some exceptional instances. In that reign two statutes were passed (32 Hen. VIII. c. 1 and 34 & 35 Hen. VIII. c. 5) which authorised testators to devise their lands held in socage, and two third parts of their lands held by the then existing military tenure of knight's service; and the abolition of military tenures in 12 Ch. II., by converting all fee simple estates into socage tenure [TENURE], had the incidental effect of rendering them all devisable by will. The power of making a will over personal property existed from a much earlier period, although anciently a man could not dispose by will of more than one third part of his general personal property, if he left a wife *and* children, or of more than half if he left either wife *or* children. This ancient rule, however, gradually became subject to many exceptions by the effect of local customs, until the rule itself took the place of an exception, and became confined to such places as had a custom in its favour, and even in those places it was ultimately abolished by a series of statutes, the last of which was 11 Geo. I. c. 18. Ever since the passing of the Statute of Frauds (29 Ch. II. c. 3) it has been necessary that wills of real property should be in writing; but nuncupative or verbal wills of personal property were, previously to the year 1838, admitted under certain restrictions, which, however, were so stringent that such wills had become practically obsolete.

The Act of 1837 for the amendment of the laws with respect to wills (7 Wm. IV. and 1 Vict. c. 26) is now the governing statute as regards wills in England and Ireland. All wills (except those of seamen and soldiers on service), whether of real or personal property, must be in writing, and signed at the foot by the testator or some other person in his presence and by his direction; and such signature must be made and acknowledged by the testator in the presence of two or more witnesses present at the same time; and such witnesses must attest and subscribe the will in the presence of the testator. All appointments by will, whatever formalities may have been required by the creator of the power, must now be made according to the provisions of this statute, and require no further form. The same statute enacts that no will of a minor shall be valid. All devises and gifts by will to an attesting witness, or to the husband or wife of an attesting witness, are void. Wills can now be revoked only by the marriage of the testator, or by another will duly executed, or some writing declaring an intention to revoke, and executed in the same manner as a disposing will, or by burning, tearing, or otherwise destroying by, *or* in the presence and by the direction of, the testator, with intention to revoke. All wills now speak (with reference to the property comprised in them) from the death of the testator, unless they show on the face a contrary intention, i. e. the will acts upon the property which he possesses at his death.

A married woman cannot make a will of lands or tenements; nor, without the consent of her husband, of personalty, unless in either case she is authorised to do so by some special power of appointment.

A disposition by will of real property is termed a *devise*; of personal property, a *bequest* or *legacy*. The death of a devisee or legatee in the lifetime of the testator has in most cases the effect of causing the devise or legacy to *lapse* or fail.

In the construction of wills the courts have, from a wish to carry out the intention of testators, deviated in some few respects from the technical rules applicable to other dispositions of property. The effect of this has been, however, to create a most erroneous impression, less general perhaps now than formerly, that any testamentary disposition, however informal, may be relied upon to carry out the real intention of its framer, although such intention be expressed in careless or inaccurate language, or even left to be inferred from a presumed knowledge of the testator's family or circumstances. So far, however, is this from being the case, that it may be confidently stated that there are no documents so difficult to prepare as wills, none which require more care or deliberation, none whose construction is so frequently the subject of litigation. Every testator who wishes to feel reasonably sure that his intentions will actually be carried out, should be careful, in the first place, to frame his proposed testamentary dispositions in a manner as simple and free from complication as the circumstances of his family will admit of; and, secondly, to have those dispositions put into formal shape under able and deliberate professional advice.

In Scotland, the right of bequest, strictly so called, is confined to personal property, although real or heritable property, which includes many securities for money, and other

particulars ranked in England with personal property, may be disposed of by a deed of settlement of a testamentary nature, executed with certain formalities.

According to French (and, in general, civil) law, a will may be either *holograph*, i. e. written as well as signed by the testator; *public*, i. e. *received* by a notary in the presence of four witnesses (or two notaries with two witnesses); *mystic*, i. e. secret, which may be presented, sealed, to a notary in the presence of six witnesses. In France, however, a testator cannot dispose by will of more than the quotité disponible of his property, viz. half if he leaves one child, a third if he leaves two children, a fourth if he leaves three or more children; and the testamentary power is subject to many other restrictions. There is, indeed, probably no legal system under which testators enjoy a more unfettered power of disposing of their property by will, than they do under the English law, and it may even be urged that this liberty, by the complicated settlements or dispositions of which it admits, has materially restrained the free alienation of estates, and thus in some measure defeated its own object.

Will, Freedom of the. The doctrine of the freedom of the human will is generally maintained as the antithesis to the doctrine of Necessity. The difficulty of the doctrine is felt only in reconciling it to absolute foreknowledge in God. This difficulty Professor Mansel meets by saying that (like eternity and continuous duration, everlasting purpose, and accessibility to prayer, perfect action yet unexhausted power to act), 'complete foreknowledge, coexisting with human freedom, may be classed among elements which we cannot combine into a single whole, but which we can believe are capable of such combination.' Professor Bain, on the other hand, in his work on *The Emotions and the Will*, asserts that this position involves a complete misapprehension of the terms of the question, and maintains that the words *liberty* and *necessity* are utterly misapplied in speaking of human will and action, these terms being metaphors converted into scientific language, while the mental processes to which they are referred may, with as good reason, be described as 'circular or oval, wet or dry.'

Williamite. [WILHELMITE.]

Williamsite. A variety of Serpentine met with, of a pale green colour, at Haroldswick, in Unst, one of the Shetlands, with chromate of iron; and also at Westchester, in Pennsylvania, where it was first discovered by L. Williams, after whom it is named.

The name Williamsite has also been applied by some mineralogists to the native silicate of zinc, Wilhelmite or WILLEMITE.

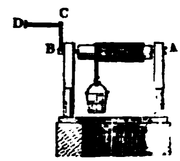
Willow. [SALIX.]

Wilson's Theorem. This theorem expresses a characteristic property of prime numbers, and may be thus ennunciated: The continued product, increased by unity, of all the integers less than a given prime is exactly divisible by that prime. Thus $1+1.2.3.4.5.6 = 721$ is exactly divisible by 7. No composite number could possess this property, since, being obviously a divisor of the continued product in question, it must necessarily be prime to that product increased by unity. Wilson's theorem may be easily deduced from FERMAT'S THEOREM; its demonstration is given in all text-books.

Wilsonite. A mineral of a rose-red or peach-blossom colour, named after Dr. Wilson, by whom it was discovered in the township of Bathurst in Canada. It bears some resemblance to Scapolite, and is a hydrated silicate of alumina, with potash and small quantities of soda and lime.

Wiluite. A name given to Grossular, from its occurrence near the river Wilui, in Siberia. [GARNET.]

Winch. A machine used for many common purposes. It is a particular modification of the wheel and axle, the power being applied by means of a rectangular lever or cranked handle. The arm B C of the winch represents the radius of the wheel; and the power is applied to C D at right angles to B C. This is the simplest form of winch, and is used for drawing water out of wells or foundations, and for other simple purposes. But for lifting heavier weights, wheel work is introduced into the construction of the winch, and, in many cases, small steam engines are employed for driving it. Steam winches are much employed in modern vessels for the removal of cargo from the holds.



Winchester Bushel. The local importance of Winchester, as the capital of the southern Anglo-Saxons, is illustrated by the universality with which the bushel of this city was accepted in the middle ages, and the steadiness with which it held its ground against the Windsor or royal bushel.

The Winchester bushel of 2150·42 cubic inches was the legal measure for centuries. The executive, from the time of the Anglo-Norman kings, gave such pains as they could in order to secure exactness in this measure. Thus, as early as the time of Richard I. it was provided that bushels should have iron rims, so that no fraud should be practised on buyers and sellers. The assize of measures was a perpetual matter of supervision in the manor court. The delinquencies of more important persons were chastised by other remedies. The inspection of measures was part of the coroner's duty, and even of the justices in eyre. Negligence in exacting due conformity to the various statutes which regulated measures would, in the case of the lord of a fair or market, work a forfeiture.

There are not, it appears, any existing measures more ancient than the reign of Henry VII. One, which was asserted to have been as

old as the days of King Edgar, and which is figured in Milner's *Antiquities of Winchester*, has, it seems, disappeared. But there are two measures of the reign of Henry VII. preserved in the Exchequer Office, one of which, being that of 12 Henry VII., contains about 84 cubic inches less than the imperial bushel, and about 26 cubic inches less than the modern Winchester standard. Another, preserved in the museum at Winchester, is only about 3 cubic inches less than the amount named above as representing the quantity of the Winchester bushel. There is a Winchester peck, also, in the Ashmolean Museum, at Oxford, which is even larger than the imperial standard.

It is said that the standard of Elizabeth corresponded exactly with the standards of Edward III. and Henry VII. The origin of the Windsor bushel is to be assigned to the custom of *purveyance*, the crown purchasing by its own bushel and quarter, and taking an advantage of one in twenty. In course of time the quantity in excess was reduced, and the uneven imperial bushel stands to the old Winchester measure in nearly the proportion of 32 to 31.

The Winchester bushel is still used in the United States. For further particulars on ancient measures, see Professor Rogers' *Agriculture and Prices*, vol. i. ch. x.; and Short *On Weights and Measures.*

Wincing Machine. The reel by which the dyer winds various articles through the dyeing vat or copper.

Winds (Lat. ventus). Currents in the atmosphere conveying air with more or less velocity from one part to another. A contraction or expansion in one part of the atmosphere, such as is caused by a variation in temperature, or by an increase or diminution in the quantity of aqueous vapour suspended in the air, will disturb the equilibrium, and produce a wind.

The theory of winds is exceedingly complicated, but the collected observations of many years have enabled meteorologists to trace certain laws even in the variable and apparently irregular winds. The most general of these laws is the *law of rotation* enunciated by Dove. This observer has shown that, from the two main currents of air—one from the poles to the equator, and the other from the equator to the poles—all other winds are derived, the modifications being caused by the relative distribution of land and water.

Winds may be divided into three classes: 1. Permanent winds, as the trade winds of the torrid zone. 2. Periodical winds, as the monsoons of the Indian Ocean. 3. Variable winds, as the winds of the temperate and frigid zones.

Permanent Winds are the winds of the torrid zone, which are caused by the solar heat and the rotation of the earth. If the earth were a sphere of uniform temperature, and at rest in space, the atmosphere would also be at rest; its height would be constant over every point of the earth's surface, and its density and elasticity at equal altitudes everywhere the same. But if the temperature of the motionless sphere, instead of being equal at every point, were greatest at the equator, and decreased towards the poles, then, though the pressure on every point of the surface would still continue the same, the altitude of the atmospheric column would become greatest at the equator, and consequently its specific gravity less there than at the poles. The heavier fluid at the poles would then, by virtue of its greater weight, pass beneath and displace the lighter, and a current be established in the lower part of the atmosphere from the poles towards the equator. In the higher regions of the atmosphere the effect would be reversed. The lower stratum of air in the equatorial regions being heated by its contact with the earth, becomes rarefied and ascends, and thus produces an accumulation, and causes a counter current in the higher regions from the equator towards the poles.

If we now suppose the sphere to revolve about its polar axis, an apparent modification will take place in the directions of the currents. If we consider places of different latitudes on the sphere, we find the velocity increases as the cosine of the latitude in going from the poles to the equator. A wind coming from the north will have a less velocity east than the places which it enters, and will, in consequence, be deflected towards the west. Thus the lower current, which, if the earth were at rest, would blow from the north, in consequence of the rotation of the earth, blows from a point more and more east. With the upper current exactly the opposite takes place. The air is thus carried back to the quarter whence it came, having veered all round the compass, blowing mostly in one direction, viz. that of the sun. This is the theory of the *trade winds*, which prevail within and to a considerable distance beyond the tropics in both hemispheres. These currents, however, receive important modifications, both as to their direction and the distance to which they extend, from the variation of the sun's declination and the configuration of the land. They prevail in the open ocean, in the Atlantic and Pacific, between the latitudes of 30° N. and 27° S. On entering this zone from either side, the deviation arising from the rotation of the earth towards the east is greatest; and this deviation becomes less and less as the equatorial zone is approached. In the immediate vicinity of the zone, the wind is nearly due north on the northern side of the equator, and nearly due south on the southern side. [TRADE WINDS.]

The zone of maximum temperature separates the circuits of the northern and southern currents of cold air, so that each current performs its own circuit. All places between the tropics will be for part of the year in the northern trade wind, and for part of the year in the southern trade wind. These periods are separated by intervals at which there is no particular direction of the wind. At the equator, both the northern and the southern currents are of the same length; north of the equator,

the northern current is the longer; south of the equator, the southern current is the longer; and at the tropics only one current occurs, interrupted by a calm at the time of the solstice.

The place of meeting of the northern and southern currents is thrown north of the equator, for, owing to the unequal distribution of the land, the mean temperature north of the equator is higher than that south of the equator, and consequently the relative masses of air in the two hemispheres differ.

The existence of an upper trade wind was first asserted by Halley in 1686. The upper trade wind has not been reached in the torrid zone; nevertheless, its existence has been proved beyond dispute. On the 30th of April, 1812, after an explosion had been heard at Barbadoes, ashes fell so thickly as to break down the trees. The trade wind was at its height, and it was concluded that these ashes came from the volcanoes of the Azores. They came, however, from St. Vincent, 100 miles to the west. The violence of the eruption had carried the ashes through the lower trade wind to the upper. On the 20th of January, 1835, the volcano Coseguina, on Lake Nicaragua, burst into eruption with a report which was heard 1,000 miles off. Clouds of ashes enveloped the seaport town Union, on the west of the bay of Conchagua, and caused darkness for forty-three hours. Ashes also fell at Kingston and other places in Jamaica, which is N.E. of Nicaragua; hence they must have been carried by the counter trade wind. These and similar facts prove the existence of an upper current.

The upper trade, as it passes northward into cooler regions, sinks gradually to the earth, and forms the prevailing W. and S.W. winds, which makes the sailors call the journey from Philadelphia to England *down hill*. At the Peak of Teneriffe it grazes the summit of the mountain, and all travellers who have visited the peak speak of the strong S.W. wind they encounter at the summit. But the place at which the upper current reaches the earth varies with the position of the sun. It descends to the surface in summer in somewhat higher latitudes than it does in winter.

As we have already remarked, the *law of rotation* of Dove is based on the assumption that there are, properly speaking, only these two atmospheric currents on which our relations of weather depend, a polar and an equatorial current. 'Within the tropics these currents flow one over the other; but beyond the tropics they flow beside each other in variable channels; and it is the preponderance of one of these currents over the other at a given place which determines extreme circumstances or conditions in respect to temperature, and their contest and alternate prevalence which determines the changeable character of the weather of our own countries. The *law of rotation*, as deduced from observations, is thus stated by its author: 'In the northern hemisphere, when polar and equatorial currents succeed each other, the wind veers, in general, in direction S., W., N., E., S. round the compass. Exceptions to this rule are more common between S. and W. and between N. and E. than between W. and N. or between E. and S. In the southern hemisphere, when polar and equatorial currents succeed each other, the wind veers, in general, in direction S., E., N., W., S. round the compass. Exceptions to this rule are more common between N. and W., and between S. and E., than between W. and S. or between E. and N.' (Dove *On the Distribution of Heat over the Surface of the Globe.*)

Periodical Winds.—In the Indian Ocean the trade winds receive a curious modification from the position of the surrounding land, and the effect of the solar heat on it. During one half of the year, from November to April, the winds blow in the ordinary direction of the trades, i. e. from the N.E.; but from April to November they blow in the directly opposite direction. This phenomenon is thus explained. The place of meeting of the two trade winds varies with the position of the sun; consequently, at places between the limits of this variation periodic winds blowing in exactly opposite directions are produced. These winds are called MONSOONS. The S.E. trade wind, as we have seen, owes its easterly direction to the fact that it moves towards points which have a greater velocity than the points from which it blows. These conditions are changed as soon as the wind crosses the equator, and the S.E. trade wind becomes the S.W. monsoon. Similarly the N.E. trade wind becomes the N.W. monsoon.

Between the equator and 10° south latitude, N.W. winds prevail from October to April, and S.W. the rest of the year. In other parts of the tropics, the regular trade winds are also modified by the configuration of the land. On the coast of Guinea the wind almost constantly blows from the S.W., in the opposite direction to the trades. Near the Cape Verd Islands calms and variable winds are usually experienced. Between the parallels of 30° and 40°, in both the North and South Pacific Oceans, westerly winds blow almost constantly, excepting only for a short time after each equinox. In the North Atlantic Ocean the prevalence of westerly winds between those parallels is less constant, in consequence of the comparative narrowness of that ocean, and the consequent influence of the opposite continents; they are still, however, the prevailing winds, except in the months of April and October, when a N.E. wind is more frequent.

Variable Winds.—According to the *law of rotation*, even the variable winds of high latitudes are merely occasional deviations from the two main directions. Beyond the trade wind zone, these winds continue to move in parallel channels. 'The characteristic differences of these currents may always be traced to their difference of temperature, and to the differences in the action exerted by the earth on them in their course.' When the two opposite currents come into collision, a rotatory motion is often produced; and thus arise revolving storms or *cyclones*. [STORM.] It is a disputed

point whether the storms of the British Isles occur according to this rotation theory. Sudden and violent local winds are produced by the rarefaction which attends the precipitation of aqueous vapour. The condensation into drops creates an immense void, the filling up of which must necessarily occasion violent atmospheric changes. Hence it is that an unusual fall of the barometer is generally followed by a gale of wind.

The different manner in which land and water are affected by radiation and the direct heat of the sun gives rise to the *land* and *sea breezes* which prevail on the coasts. They occur chiefly in tropical countries, though they are not confined to any particular latitude, and are perceptible sometimes as far north as Norway. During the day the surface of the land becomes more heated than that of the adjacent ocean, and the air over the land, in consequence of its greater rarefaction, is displaced by the denser air rushing from the sea. Hence a current, or *sea breeze*, beginning at some hour in the morning, and continuing till the sun is near setting, will flow from the water towards the land. At night the water remains warm, while the surface of the land cools rapidly; and hence the current sets from the land towards the water, and forms the *land breeze*. Winds of this sort are more frequent about islands and small peninsulas than in other situations. In mountainous districts periodic daily breezes also occur, probably produced by the copious nocturnal radiation from the summits of the mountains.

A variety of local winds have received particular names. The *Etesian* is a northerly or north-easterly wind, which prevails very much in summer all over Europe. The *Sirocco* is a hot, moist, and relaxing wind, which visits Naples and the south of Italy from the opposite shores of the Mediterranean. The *Samiel* or *Simoom* of Arabia is a hot, arid, pestilential blast, generally coming from the south. The *Kamsin* of Egypt is of the same kind. The *Harmattan* is a dry east wind, also of an unwholesome character, occurring in Guinea and some other countries.

Velocity of the Wind	Perp. Force on 1 Sq. Foot, in Lbs. Avoirdupois	Common Appellation of the Force of such Winds
Miles in an Hour		
1	·005	Hardly perceptible.
4	·079	Gentle pleasant wind.
5	·123	
10	·492	Pleasant brisk gale.
15	1·107	
20	1·968	Very brisk.
25	3·075	
30	4·429	High wind.
35	6·027	
40	7·873	Very high.
50	12·300	A storm.
60	17·715	A great storm.
80	31·490	A hurricane.
100	49·200	A violent hurricane.

The velocity of the wind varies from almost nothing to upwards of a hundred miles an hour; but the maximum is variously stated by different experimenters. In vol. li. of the *Philosophical Transactions* a table is given of the different forces and velocities of winds, drawn up by Smeaton from a considerable number of facts and experiments, by the assumption that the pressure varies as the square of the velocity. An extract from it is given above.

(Prof. Forbes' *Reports on Meteorology* to the British Association for 1831 and 1840; Experiments by Col. Beaufoy in the *Annals of Philosophy*, vol. viii. p. 94; Daniell's *Meteorological Essays*; Murray's *Geography*, Introd.; Pouillet, *Elémens de Physique*; and *Greenwich Meteor. Obs.*; Dove *On the Distribution of Heat* and *On the Laws of Storms*; Colonel Reid *On the Laws of Storms*; *Meteorology*, by Jenyns; Herschel's *Meteorology*; Maury's *Physical Geography of the Sea*; Fitzroy's *Weather Book*; and Buff's *Physics of the Earth*, edited by Hoffmann.)

Wind-sail. A tube or funnel of canvas, employed to convey a stream of fresh air down into the lower parts of a ship.

Wind-gauge. An instrument for measuring the force or velocity of the wind. [ANEMOMETER.]

Windage. In Gunnery, windage is strictly the difference between the area of a section of the bore at right angles to its axis, and the area of a great circle of the shot. It is, however, generally estimated by linear measurement, and is then taken as the difference between the diameter of the bore and that of the shot.

Windlass. A contrivance used in many vessels, instead of a capstan, for raising the anchor or lifting other heavy weights. It usually consists of a horizontal polygonal beam of timber, supported at a short distance above the deck by strong uprights called *windlass-bitts*, and in the older forms of the machine it is rotated by means of short poles called *hand-spokes*, which are introduced into mortices in the body of the windlass, and by which it is turned round, winding up the chain-cable as it revolves. To prevent the windlass from turning back when the strain of the chain comes upon it, a strong ratchet-wheel is fixed on its centre, into the teeth of which a number of *palls*, hinged on an upright timber called the *pall-bitt*, fall as the wheel revolves. Modern windlasses are rotated either by wheel-work or by a ratchet or friction contrivance, moved by handles like those of a pump, which catch a wheel on the windlass and turn it round through a certain distance at each stroke. Brown's capstan, however, in which there is a suitable indented groove for receiving and holding each link of the chain-cable as the capstan revolves, is now usually preferred to the windlass.

Windmill. In Mechanics, a mill which receives its motion from the impulse of the wind, the oblique sails forming virtually a great screw of four threads, which the wind puts into revolution. The building containing the machinery is usually circular. To the extremity

of the principal axis, or wind-shaft, are attached rectangular frames, generally four, on which cloth is sometimes stretched to form the sails; but the sails are now more usually made of wooden lattice work, like Venetian blinds, which may be opened in high winds to let part of the wind through. The surfaces of the sails are not perpendicular to the axis, but inclined to it at a certain angle, about 72° at the extremities nearest the axle, and 83° at the further extremities; so that their form is in some degree twisted, and different from a plane surface. If we suppose the axis to be placed in the direction of the wind, the wind will then strike the sails obliquely, and the force may therefore be resolved into two parts, one of which, acting in the direction perpendicular to the axis, gives a motion of rotation to the sails, and consequently to the main shaft, from which it is communicated to the machinery. The main shaft is inclined to the horizon in an angle of from 8° to 15°, chiefly in order to allow room for the action of the wind at the lower part, where it would be weakened if the sails came too nearly in contact with the building.

As the direction of the wind is constantly changing, some apparatus is required for bringing the axle and sails into their proper position. This is sometimes effected by supporting the machinery on a strong vertical axis, the pivot of which moves in a socket firmly fixed in the ground; so that the whole structure may be turned round by a lever. But it is now usual to construct the building with a movable roof, which revolves upon friction rollers, and the shaft being fixed in the roof, is brought round along with it. The roof is brought into the required position by means of a small vane wheel furnished with sails, which turns round when the wind strikes on either side of it, and drives a pinion which works into the teeth of a large crown wheel connected with and surrounding the movable roof. This wheel will settle itself where there is the minimum of motion imparted to it, which will be in the line in which the wind is blowing; and the main sails are by this expedient constantly made to face the wind.

Of the Form and Position of the Sails.—From the investigations of Parent and Belidor, it appears that the maximum effect of the wind on the sails is produced when their inclination to the axis of rotation is about 54¾ degrees; or when the *angle of weather*, i.e. the angle formed by the plane of the sail and the plane of its revolution, is 35¼ degrees. But this result, being obtained from considering the effect of the wind on the sails when at rest, does not agree with that which is found by experiment. In fact, as the velocity of the sail tends to withdraw it from the action of the wind, it is necessary to counteract the diminution of force by diminishing the angle of weather, or to bring the sail into such a position that the wind may strike its surface more directly; and since the velocity of the different parts of the sail is in proportion to their distance from the axis, it follows that in order to produce the greatest effect every elementary portion of it ought to have a different angle of weather, diminishing from the centre to the extremity of the sail. Euler has given a theorem which determines the law of variation. Let a be the velocity of the wind, and b the velocity of any given part of the sail; then the action of the wind upon that part of the sail will be a maximum when the tangent of its inclination to the axis, or the cotangent of the angle of weather,

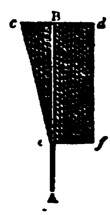
$$=\sqrt{2+\left(\frac{3\,b}{2\,a}\right)^2}+\frac{3\,b}{2\,a}.$$

Suppose that at a given part of the sail the velocity of the sail is equal to the velocity of the wind, we have then $a=b$; and the formula becomes

$\sqrt{2+\frac{9}{4}}+\frac{3}{2}=3{\cdot}561=$ tangent of 74° 19′, which gives 15° 41′ for the angle of weather.

This subject was investigated experimentally by Smeaton (*Phil. Trans.* vol. li.), who found that the common practice of inclining the sails from 72° to 75° to the axis is much more efficacious than the angle assigned by Parent, the effect being as 45 to 31. When the sails were weathered in the Dutch manner, or with their surface concave to the wind, and the angle of inclination greater towards the extremities, the effect was greater than when weathered either in the common way or according to Euler's theorem. But the effect was greatest when they were enlarged at their extremities, and had the form *c d f e*, represented in the annexed figure; so that *c d* was one-third of the radius A B, and *c* B to B *d* as 5 to 3. If the sails be farther enlarged, the effect is not increased in proportion to the surface; and besides, when the quantity of cloth is great, the machine is much exposed to injury from sudden squalls. In Smeaton's experiments the angle of weather varied with the distance from the axis; and it appeared from several trials that the most efficacious angles at the different parts of the sail were those in the following table:—

Fig. 1.



Parts of A B, which is divided into Six equal Parts	Angle with the Axis	Angle of Weather
1	72°	18°
2	71	19
3	72	18
4	74	16
5	77½	12½
6	83	7

If the radius A B of the sail be 30 feet, then the sail will commence at ⅙ of A B, or 5 feet from the axis, where the angle of inclination will be 72°. At 10 feet from the axis, the angle will be 71°; and so on, as in the table. In point of fact, the surfaces of windmill sails should be helical, or nearly so, while they

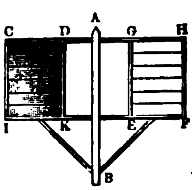
are in action. But as they are twisted somewhat by the action of the wind itself, the surfaces are not helical when at rest, but are more nearly so when in motion. In the best forms of mill, the Venetian work, of which the sails are composed, is so made that it is opened partly by the increased centrifugal force when the mill runs at a high speed.

Of the Effect of Windmill Sails.—The following maxims relative to the effect of the sails were deduced by Smeaton from his experiments:—

1. The velocity of windmill sails, whether loaded or unloaded, so as to produce a maximum effect, is nearly as the velocity of the wind, their shape and position being the same. 2. The load at the maximum is nearly, but somewhat less, as the square of the velocity of the wind, the shape and position of the sails being the same. 3. The effects of the same sails at a maximum are nearly as the cubes of the velocity of the wind, but somewhat less. 4. The load of the same sails at the maximum is nearly as the squares, and their effects as the cubes of their number of turns in a given time. 5. When the sails are loaded so as to produce a maximum effect at a given velocity, and the velocity of the wind increases, the load continuing the same, then the increase of effect, when the increase of the velocity of the wind is small, will be nearly as the square of those velocities; when the velocity of the wind is doubled, the effect is nearly as 10 to 27½. When the velocities compared are more than double of that where the given load produces a maximum, the effects compared increase nearly in the simple ratio of the velocity of the wind. 6. In sails where the positions and figures are similar and the velocity of the wind the same, the number of turns in a given time will be reciprocally as the radius or length of the sail. 7. The load at a maximum that sails of a similar figure and position will overcome at a given distance from the centre of motion will be as the cube of the radius. 8. The effects of sails of similar figure and position are as the square of the radius. 9. The velocity of the extremities of Dutch sails, as well as of the enlarged sails in all their usual positions, when unloaded, or even loaded to a maximum, is considerably quicker than the velocity of the wind.

Horizontal Windmills.—Windmills are sometimes constructed in such a manner that the planes of the sails intersect each other in the wind-shaft, in which case they are called *horizontal windmills*; because the wind-shaft being usually vertical, the sails have a horizontal motion. In this construction A B is the wind-shaft or arbor, which moves upon pivots. Cross-bars are fixed in this arbor, which carry the frames C D I K and G H E F. The sails

Fig. 2.



C K and G F are stretched on these frames, and are carried round the axis A B by the perpendicular impulse of the wind; and a toothed wheel fixed upon the arbor gives motion to the machinery. Two sails only are represented in this figure, but there are always two others at right angles to these. When the wind impels the two sails C K and G F equally, it is obvious that no motion can ensue. In order, then, that motion may be communicated to the machine, the impulse of the wind on the returning sail must be removed, either by screening it from the wind, or by making it present a less surface when returning against the wind. The first of these methods is said to be practised in Tartary, Persia, and some provinces in Spain. The other method was contrived by Hooke, and acts in the same way as a feathering paddle-wheel. Horizontal windmills, however, are greatly inferior to vertical, and even the last are going out of use, the steam engine being so much preferable as a prime mover, and being now so widely available.

Window (Dan. vindue, Span. ventana). In Architecture, an aperture in a wall for the admission of light and air to the interior. In distributing windows so that there be had a sufficiency of light, it is usual to make the piers or intervals between them never less than the width of the window, and never more than two widths of the same. Where it is required to ascertain the total area of light necessary for a room, the following empirical rule is frequently used: Multiply together the length, breadth, and height, and extract the square root of the product, which will be the area of light required.

Window Tracery. [Tracery, Window.]

Wine (Lat. vinum, Gr. *οἶνος*). The fermented juice of the Grape Vine, *Vitis vinifera*. The alcoholic strength of wine depends on the amount of glucose or grape sugar contained in the must; its flavour on certain essential oils produced in the grape itself when it has reached maturity, or perhaps on some ethers developed at once in the process of fermentation, or more slowly as the wine ripens by age. The latter is probably the true explanation of what is called the *bouquet* of wine, for common wines, though they may be often kept for an indefinite period, do not improve by age, while the highest class of wines become, within certain limits, much better by keeping.

The home of the grape is apparently Syria. It will not flourish in tropical regions; and though it grows luxuriantly even in the colder portions of the temperate zone, it will not ordinarily ripen its fruit higher than at about the 42nd degree of latitude in the Old World, the isothermal line in the New World being lower. It was not, it seems, cultivated in the plains of Mesopotamia, and it appears to have been slowly introduced even into Italy, if we are to trust the accounts given of the simple life of the Italian peasantry in the second century B.C. It is said to have been brought into France by Probus; and, according to common report, the best vintages of that country are even now

obtained from spots which had been selected originally by Italian cultivators. Such, for instance, is the Romanie Conti of Burgundy.

The vine grows best on exposed hills, on a light, calcareous, and especially on a volcanic soil, and with a south-east aspect. The nature of the soil is everything with the wine produced; for while the produce of a particular spot may be of the highest market value, that which is grown a few yards from the mysterious boundary may be almost valueless. No analysis of the soil of the best vineyards has given any clue to this remarkable difference in produce. All that is known is matter of experience, though as the juice of the grape always contains a notable quantity of cream of tartar in solution, which is deposited as the wine ripens, it is clear that the soil must contain potash.

The manufacture of the wine, and the manipulation of the grape harvest, are matters of careful and anxious interest to the vine-grower. A bad vineyard will not, of course, produce good wine, but the produce of the best vineyard may be spoiled by bad management or unskilfulness. The vintages most famous in antiquity have become poor or worthless. Either other localities have been more favourable, or the skill of the vinedresser has declined in Italy and the Ægean, for certainly the modern Falernian and Chian wines are very poor. At present, with the exception of Monte Fiascone, there is hardly a good Italian wine in the market, and the vintages of grapes must be manipulated in a very different manner from that to which they are subjected at present before they attain any reputation. It would be impossible, however, in a work like this, to give any account of the various wines which in increasing numbers are commended to the British public. The reader will find abundant information in the *Commercial Dictionary*.

Use of Wine in England.—In early English history, almost all the foreign wine (for some was manufactured at home) was imported from Bordeaux. From the time of our Henry II. to the rupture of the peace of Bretigni, a period of more than two centuries, Guienne was a dependency of the English crown, the intercourse between this country and the whole western sea coast of France was constant, and the commercial relations were very close. Wine was very cheap, and lay within the means of all but the poorest classes of society, being sold freely and generally at from 2*d.* to 3*d.* the gallon in money of the time, this sum being the ordinary wages of a day labourer. After the conquest of Guienne, at the close of the fourteenth century, the price was doubled. Spanish and Greek wines were known, but were dear, and rarely imported.

The constant wars between this country and France, and the frequent interruption of commercial relations, made the wine trade subject to violent fluctuations; but claret, i.e. Red Bordeaux, was the common wine of people in England till the negotiation of the Methuen treaty practically excluded the weaker produce of France by the enactment of what was in effect a prohibitive duty. The treaty was reluctantly acceded to, even by the stanchest friends of the New Settlement. It caused great discontent in Scotland, but it is believed that its terms were evaded by smuggling, a practice which at this time generally fell in with the tastes and political sympathies of the Scotch, who were dissatisfied at being debarred from the use of their favourite beverage, and not disinclined to cripple the resources of the new dynasty by avoiding as far as possible any contribution to the revenue. For many a year the charges of the customhouses at Leith and elsewhere exceeded the receipts.

The exigencies of the wars of the eighteenth century, and finally of the great continental struggle, led, along with many other fiscal expedients, to the extension of the duties on wine. They were raised from 4*s.* 10*d.* on French and 3*s.* 1¾*d.* on Portuguese growths, at which they were in 1794, to 10*s.* 6*d.* on French and 6*s.* 1*d.* on Portuguese; and in 1804 to 13*s.* 9*d.* and 8*s.* 10*d.* It is hardly necessary to say that the effect was a great diminution in consumption (the duties being so absurdly high that they almost amounted to prohibitions); a considerable developement of smuggling, and a general substitution of spirits for wine. In 1825, however, the duties were reduced to 7*s.* 3*d.* on French, 4*s.* 10*d.* on all other foreign wines, and 2*s.* 5*d.* on Cape produce. In 1831 the duties on all foreign wines were equalised at 5*s.* 6*d.*, and Cape wines charged 2*s.* 9*d.*

In course of time a general demand was made that the wine duties should be reconsidered, many persons advocating a uniform tax of 1*s.* the gallon, others suggesting an ad valorem duty, others an alcoholic duty. The last of the plans, and obviously that which is the most practicable, and, under the circumstances, the most just, was adopted in 1860. It is clear that, especially in a commodity like wine, the market value of which depends on fashion, and varies with age, the imposition of an ad valorem tax would have been very difficult, if not impossible. The government, therefore, proposed that all wines containing 25 per cent. and upwards of proof spirit should pay 2*s.* a gallon, those which contained less 1*s.*, the avowed object of the change, concurrently with the negotiation of the French commercial treaty, being the encouragment of light wine consumption. Sufficient time has hardly elapsed since the change, to give any proof as to the success of the experiment; but the revenue has suffered very little loss, and bids fair soon to reach and exceed the amount derived before the change. It is singular, however, that although the alcohol contained in wine is much less lightly taxed than that in spirits, the consumption of the latter has greatly increased. The duty on bottled wines, put in 1860 at the highest rate, was in 1866 reduced in the case of wines below 25 per cent. to the lower rate, the change having been provided by the terms of the Austrian commercial treaty.

Wing (A.-Sax. gehwing). In Architecture. [Alæ.]

Wings. In Botany, certain membranous expansions of different parts of plants. The two lateral oblong petals of a Papilionaceous corolla, the two lateral sepals of a *Polygala*, the expansion from the back of the fruit of the Ash-tree, from the sides of the seed of a *Bignonia*, and from the surface of many Umbelliferous fruits, are all called *wings*; as also are the membranes sometimes projecting from the angles of certain stems or leaf stalks.

Wings. In Military operations, the flank portions of an army, as distinguished from the centre. Each regiment is also divided into two portions, called the *right* and *left wings*.

Wings. In ships, wings are passages along the sides of the ship between the fore and after cockpit, to give the carpenters ready access to any leak.

Wing-transom. In a ship with a square stern, that transom on which the main body of the stern rests.

Winna. An Indian name for layers of the dried bark of *Lecythis Ollaria*, used in Guiana as wrappers for cigarettes.

Winter (a Teutonic word). One of the four seasons of the year. Winter is usually understood to begin with the shortest day, and to end when the sun returns to the vernal equinox.

Winter's Bark. The bark of the *Drimys Winteri*, or *Wintera aromatica*, a large forest tree growing in Chili, Peru, and New Granada, and which was first brought to England by Captain Winter, who accompanied Sir Francis Drake, in 1578, to the straits of Magalhaens, where he obtained his specimens. It is found in the market in large quills or rolled pieces of a dull yellowish grey colour, and has an aromatic odour and warm pungent flavour. It was at first confounded with *Canella bark*, which it much resembles in appearance and flavour, but its inner surface is reddish brown, whereas that of Canella is much paler, and solution of sulphate of iron gives a precipitate in its infusion, but not in that of canella. Canella is the bark of the *Canella alba*, a large tree growing in the West Indies and America.

Winter-green. The *Chimaphila umbellata*, a plant which, under the name of *Pipsissewa*, was first used medicinally by the aborigines of America. The infusion of the dried leaves is tonic and diuretic. It has been found useful in some chronic affections of the urinary organs. The name *winter-green* is also given to Gaultheria.

Wipers. In some kinds of Machinery, as oil-mills, powder-mills, fulling-mills, pieces projecting generally from horizontal axles, for the purpose of raising stampers, pounders, or heavy pistons, in vertical directions, and then leaving them to fall by their own weight. The principal object to be attended to in the construction of wipers is to give them such a form that the weight shall be raised with a motion slow at first and gradually increasing in velocity, like that of gravity; and to this end the outline of the wiper should be a parabola.

Wire-drawing. The art of extending the ductile metals into wire. The operation is performed by casting or hammering the metal into a bar, which is then successively drawn through holes in a steel plate, each being smaller than the other, until the requisite fineness is attained. The holes through which extremely fine wires of platinum, gold, or silver are occasionally drawn, are sometimes made in a diamond or ruby.

Wisby, Ordinances of. Maritime laws, principally compiled from those of Oleron. (Hallam, *Middle Ages*, ch. ix. part ii.) [Maritime Law.]

Wiserite. A hydrated variety of native carbonate of manganese (Diallogite), named after the Swiss mineralogist Wiser. It occurs in yellowish or reddish silky fibres at Gonsenz, in Switzerland.

Wish. In Teutonic Mythology, the embodiment of fruition or actual enjoyment of desire, as distinguished from mere longing. It is thus an attribute of Odin, or rather may be considered as only another name for Odin, Wish being endowed with bodily shape and powers, and rejoicing in his own works, as a father rejoices in his children. The form used to express this attribute in the Edda is Oski; and thence the word *osk* is employed as a prefix, as in *oska-steinn*, a wishing-stone, *oska-byrr* (Gr. *ἴκμενος οὖρος*), a fair wind, i.e. such a wind as a man may wish for; *oska-barn*, a wish-child, i.e. an adopted child. Thus the heroes whom the *Valkyries*, or oska-mær, guide to the *Walhalla*, are Odin's oska-barn, or choice children. This power of wish marked the spear of Odin, the hammer of Thor, which after doing its work returned of itself to his hand, and the necklace of Freya, which answers to the cestus of Aphroditè. (Dasent, *Popular Tales from the Norse*, xciii.) In a remarkable Vedic hymn, cited by Professor Max Müller, in his *History of Sanscrit Literature*, p. 561, the same idea apparently is conveyed by the word *kama*, in describing the work of creation. This word, which he translates by the term *love*, Professor H. H. Wilson interprets as wish, or desire. (*Edinburgh Review*, Oct. 1860, p. 384.)

Wistaria (after Caspar Wistar, Professor of Anatomy at Pennsylvania). A genus of climbing shrubs of the order *Leguminosæ*, natives of North America, Japan, the northern provinces of China, &c. Two species are well known, and largely grown in this country for the sake of their elegant racemes of lilac flowers, which are produced in great profusion when the plant is trained over on a south wall or other sheltered spot. *W. sinensis*, the Chinese species, has larger and paler flowers than those of *W. frutescens*, the American kind, the flowers of which, moreover, are slightly scented, and have a greenish spot at the base of the standard.

Wistit. [Ouistitis.]

Wit (A.-Sax.; akin to Ger. wissen, Lat. videre, Gr. ἰδεῖν, *to see*, *to know*). Wit has been defined briefly to be the unexpected combination of distant resemblances. The term *wit* has in the course of two centuries passed through more significations than most others in the English language. Without going farther back than the reign of James I., wit is used by Sir J. Davies as the most general name for the intellectual faculties. In the time of Cowley and Hobbes, it came to denote a superior degree of understanding, and more particularly a quick and brilliant reason. By Dryden it is used as very nearly synonymous with *talent* or *ability*; but after his time, and more particularly by Addison in his papers on Wit, we find a gradual approximation to the modern signification of the term. (For the difference of meaning between *wit* and *bulls*, see *Edin. Rev.* vol. iii. p. 399.)

Witch of Agnesi. In Geometry, a curve of the third order, first noticed by Maria Gaetano Agnesi in her *Istituzioni Analitiche*, Milano 1748 (translated by Colston), and called by her the *Versiera*. The equation to rectangular co-ordinates is $xy^2 = 4a^2 (2a - x)$, whence the curve may easily be traced.

Witch Meal. A popular name given to the pollen or powder sold in the shops under the name of *Lycopodium*, procured from the *Lycopodium clavatum*, or *Clubmoss*. It contains a large quantity of oily inflammable matter, and when thrown into the flame of a candle produces a sudden flash or blaze, whence it is used in theatres for imitating lightning. It has also, from its yellow colour, been called *vegetable sulphur*. In Pharmacy, it is used for enveloping pills to prevent their adhesion.

Witchcraft. The craft, cunning, or science of the wise, the words *wizard* and *witch* being connected with the Teutonic wissen, and the Greek ἰδεῖν, *to know*. [WITENAGEMOT.] But the term has been practically confined to those who are supposed to have dealings with the agencies of the spiritual or unseen world, and who thus become endowed with preternatural powers, exercised sometimes for the good, but far more commonly for the injury of mankind. This was especially the mediæval sense of the word, and it rested undoubtedly on the hypothesis that witches were enabled to do certain acts wholly by virtue of a compact with the devil or his imps. But the word is also used by the translators of the Old Testament, and it has been asserted by some that the laws enjoining the capital punishment of witches are directed merely against poisoners. But the phenomena described in such cases as that of the witch of Endor closely resemble those of modern witchcraft, while they exhibit no trace whatever of poisoning. The league of the Jewish witches with familiar spirits still further attests the identity of Jewish notions on the subject with those which were entertained through the middle ages.

For the origin of the idea it is difficult, if not impossible, to account. The power which words have exercised on the mind when their original meaning has been in part or wholly forgotten is manifest to all students of the history of language. If confusions such as those between λευκός, *shining*, and λύκος, *a wolf* —both words belonging to the same root, the brute being so named from the glossiness of his skin—may possibly have supplied the germ of notions which were afterwards expanded into the superstition of LYCANTHROPY [LYCAON; WEREWOLVES], the mysterious wisdom ascribed to the sun as seeing into all the hidden nooks and crannies of the universe, and to Phœbus Apollo as the sun-god or light-god, may perhaps furnish a clue to the notion of a wisdom which, although not naturally attainable by man, may be acquired from superior beings. Thus in the Homeric hymn HERMES is described as seeking this boon at the hands of Apollo; and although the latter cannot impart to him all his secrets, yet he grants his prayer in part, and directs him to the Thriæ, who dwell far down in hidden dales, and who will reveal to him many mysteries.

As a method of accounting for certain alleged or assumed phenomena, the hypothesis of witchcraft is not less rationalistic than the opinion which denies the possibility of such phenomena, or of the agency by which they are said to be brought about. Although there seems to be no adequate warrant for the assertion that 'everyone everywhere and always prefers the less wonderful to the more wonderful of two explanations of the same fact,' it may be safely maintained that the theory of witchcraft is an attempt to trace certain supposed results to a cause. But the preference of a natural to a supernatural causation could not present itself as an alternative to men on whose minds the idea of any order or cosmos had not yet dawned. This intellectual state characterises pre-eminently those ages to which the earlier Vedic literature [VEDA] and the Homeric poems belong. To the men of this pre-historic age the phenomena of the outward world were all brought about by a conscious and personal agency; and although some of these phenomena were of frequent occurrence, there was no reason for this beyond the arbitrary will of the personal agents. Hence the same arbitrary will accounted at once for all unusual phenomena, and for these they looked with an impatient eagerness as assurances that these agencies were not dormant. Hence if the Homeric Greek could have been supplied with a philosophical history of the past, such a history would have appeared to him, in Mr. Grote's words, 'not merely unholy and unimpressive, but destitute of all plausibility or title to credence.' (*History of Greece*, part i. ch. xvi.) A comparison of the Greek with the Jewish mind will exhibit to a certain extent the same characteristics in both, and account for the resemblances of their popular belief.

But whatever may have been the origin of the idea, its universality can scarcely be called into question. It has taken root in all coun-

tries, and gives way but slowly before the experimental results of inductive science. In almost all countries also it has led in great measure to the same results of fear, credulity, gross injustice, and cruelty.

Among the Greeks, a general belief prevailed in magical practices and incantations, especially by women; and Thessaly was the region most celebrated for the pursuit of these arts by its inhabitants. The same superstition was equally prevalent among the Romans. But, in the sense in which the word is used in modern times, a witch is supposed to derive her power from a peculiar compact with evil spirits; and this species of witchcraft is of course posterior to the rise of Christianity. The first traces of the modern superstition respecting witchcraft are perhaps to be found in Augustine, who speaks of magicians as living in society with devils, and having a compact with them. The witchcraft of more ancient times became easily connected in vulgar belief with the superstitions arising out of Christian theology. As early as the council of Ancyra (308), the belief in transformations by magical art (of which we find so remarkable an instance in the romance of Appuleius) is condemned as heretical. The gods of the ancient mythology, by the zealous preaching of the Christian clergy, acquired in popular imagination the attributes of demons; and it is possible that many of the supposed assemblies of witches and devil worshippers, which terrified the imaginations of the chroniclers and historians of saints in the early part of the dark ages, originated in the secret meetings of the proscribed worshippers of pagan deities, who endeavoured to secure their privacy by terrifying their orthodox neighbours. About the time of Charlemagne and his successors, we find one species of witchcraft peculiarly prevalent. Storms and tempests were attributed to certain magicians (defensores), who were believed to have acquired a power of controlling the elements. The very general superstition (which also is mentioned by Augustine) of assemblies of females riding through the air with the demon Diana, Minerva, or Herodias (from which, in later days, the notions of the witch festival on the Brocken in Germany, the French sabbat, &c. were all derived), is also reprobated by the divines of this period. Up to this time we have found the church generally condemning many of the popular fancies respecting demoniac agency as superstitious; but from the end of the twelfth century we find them gradually gaining ground, so as to become articles of religious credence. At the coronation of Richard I. Cœur de Lion, Jews and women were forbidden to attend: the latter because so many of them were suspected of witchcraft. The works of Gervase of Tilbury (at the beginning of the thirteenth century) give perhaps the best picture of the extent to which similar opinions prevailed about that epoch. In the same century, witches and heretics were first connected in the eye of the church: the commissioners who tried the various sectaries of the time were equally directed to enquire into and punish magical practices. In the fourteenth century the persecution of witches assumed a more regular and severe character. The well-known accusations against the Templars (1309), in which all the common charges of compacts with the devil, witch-assemblies, &c., were mingled with those of atheism and heresy, were but the prelude to a long series of similar proceedings. About this time the south of France, north of Italy, and some parts of Germany seem to have been most infested with demoniacal agency. The female sex seems from the earliest times to have been most implicated in the public horror of witchcraft; and from the commencement of the fifteenth century the decrees of councils, &c. which speak of witchcraft, are principally directed against women. From this time, therefore, we may date the separation in popular belief of the higher magic practised by learned and distinguished men, from the petty witchcraft in which the performers were poor, old, and ignorant women. Many of the great magicians were believed to operate their wonders by the control which they had acquired over inferior spiritual agents, without any express compact with the devil; and although such practices were often condemned by the church, always liable to suspicion, and sometimes brought those who indulged in them (together with alchemists and astrologers) under the cognisance of criminal tribunals, yet they were always considered as of a different order from the feats of common witches. In 1484 appeared the famous bull of Innocent VIII. 'Summis desiderantes affectibus.' In this remarkable instrument all the absurdities of the popular superstition are formally recapitulated, and a commission directed to three judges (Institor, Sprenger, and Gremper) to examine and punish witches in the German empire. Although immediately relating to Germany only, this bull is rightly considered by Herzog (the author of the article on witchcraft in *Ersch and Gruber's Encyclopædia*) as forming a period in the history of this superstition. Although much cruelty had been already committed in the pursuit of this imaginary crime, it is from this solemn confirmation of the vulgar superstition that we must date the continuous course of legal persecution which lasted for two centuries over the greater part of Europe.

So merciless was the crusade against sorcery and witchcraft, that probably its victims may be regarded as falling not far short of the numbers slain in fair field in the wars of the middle ages. 'Seven thousand victims are said to have been burnt at Trèves, six hundred by a single bishop of Bamberg, and eight hundred in a single year, in the bishopric of Wurtzburg. At Toulouse, the seat of the Inquisition, four hundred persons perished for sorcery at a single execution, and fifty at Douay in a single year. In Italy a thousand persons were executed in a single year in the province

of Como, and in other parts of the country the severity of the inquisitors at last created an absolute rebellion. The same scenes were enacted in the wild valleys of Switzerland and of Savoy. In Genoa, which was then ruled by a bishop, five hundred alleged witches were executed in three months; forty-eight were burnt at Constance or Ravensburg, and eighty in the little town of Valery in Savoy.' (Lecky, *History of Rationalism*, ch. i.)

The details of these legal proceedings bear a striking similarity in all the countries in which this baleful superstition so long prevailed. It has been seen that by the bull of Innocent VIII. witchcraft was rendered a crime peculiarly cognisable by ecclesiastical authorities; so it remained for the most part in Catholic countries, especially where the Inquisition was established; and this constituted the chief difference between the procedure in those regions and that which prevailed in Protestant districts, where the civil magistrate took cognisance of the offence. Thus the various forms of religious observance which were interwoven with the judicial proceeding in the former, exorcisms and so forth, were for the most part disused by Protestants. In other respects, the mode of investigation and punishment was much the same. Everywhere they exhibited a singular mixture of legal refinement with popular violence. Thus the various ordeals by which suspected witches purged themselves (one of the most vulgar superstitions connected with witchcraft) were conducted with gravity and regularity under the eye of the law. The best known in England was that of water; if the accused swam when thrown in, it was held as a proof of guilt. On the Continent a favourite mode, among many others, was by weighing. In the scales set apart for this purpose, a true witch was always found to weigh more than her previously ascertained weight. When, however, the suspected person was in the hands of the tribunal, there was in general one only mode of procedure—by torture. And thus everywhere the witch persecutions produced the same result—confessions, viz., of all the strange and monstrous crimes with which the accused lay charged. These appear to have grown more voluminous and more utterly incredible in every generation; and this may be naturally accounted for: for when a witch had made up her mind to confess, it cost her nothing to promulgate the most extravagant inventions; and these being regarded as undoubted truths, formed the basis of interrogatories to be administered to other unhappy beings who might be brought under the same accusation. The punishment was uniformly death, usually at the stake.

On this subject Luther expressed himself with a fury singular even in his own age. In all such cases he could see no room for compassion. All must be burnt without exception. 'In England,' says Mr. Lecky, 'the establishment of the Reformation was the signal for an immediate outburst of the superstition, and there, as elsewhere, its decline was represented by the clergy as the direct consequence and the exact measure of the progress of religious scepticism. In Scotland, where the Reformed ministers exercised greater influence than in any other country, and where the witch trials fell almost entirely into their hands, the persecution was proportionately atrocious.'

It appears, upon the whole, that the persecutions during the sixteenth and seventeenth centuries were most violent in those countries which were the scene of much strife between the two religions, or in which the Calvinist opinions were pushed to an extreme—France, the Netherlands, Northern and Western Germany, Switzerland, Scotland, England under the Commonwealth, and at a still later period New England. A singular example of the contagion of fanaticism suddenly spreading with extraordinary violence, and subsiding again after one terrible outbreak, is to be found in the history of the witch persecutions in Sweden, in the end of the seventeenth century.

The fall of paganism supplied large nourishment for the superstition, which grew to its greatest height in mediæval Christendom. The converts to Christianity, whether in Southern or Northern Europe, were not taught to question the existence of their old gods, while they renounced their worship. In Mr. Grote's words, 'The heathen gods and goddesses, deprived as they were of divinity, did not pass out of the recollections and fears of their former worshippers, but were sometimes represented (on principles like those of Euêmerus) as having been eminent and glorious men, sometimes degraded into demons, magicians, elfs, fairies, and other supernatural agents, of an inferior grade, and generally mischievous castes.' (*History of Greece*, part i. ch. xvii.) The former was the case in the north, where 'the Christian logographers felt it their duty to point out the Odin and Thor of the old Scalds as evil demons or cunning enchanters who had fascinated the minds of men into a false belief in their divinity.' Thus the whole multitude of heathen gods, nymphs, fauns, satyrs, and other beings were numbered among the diabolical agents with whom sorcerers and witches entered into compact; and the whole strength of pagan superstition went to swell the sum of credulous ideas already afloat in the minds of the early Christians. 'Wherever they turned, they were surrounded and beleaguered by malicious spirits, who are perpetually manifesting their presence by supernatural acts. Watchful fiends stood by every altar; they mingled with every avocation of life, and the Christians were the special objects of their hatred.' (Lecky, *Rationalism*, ch. i.) It needed only the notion, that these demons had those on earth who were in league with them, to open the floodgates of persecution against the supposed conspirators.

The outburst of this persecution in the latter portion of the middle ages (for up to the twelfth century the chief weapons employed against

witchcraft were charm and incantation) is by Mr. Lecky connected with the change which passed over religious thought, gradually investing the Divine nature and government with a more harsh and gloomy colouring. The Albigensian revolt against sacerdotal domination, the proclamation of doubts touching the deeper questions of the faith by Abelard, and the influence of the philosophy of Averroes, led to a general idea that the reign of Antichrist had begun, and that Satanic agency was in a pre-eminent degree operating on the affairs of men. The idea of applying relics only to stay the plague was regarded with contempt. Sterner measures were indispensable. 'The inquisitors traversed Europe, proclaiming that the devil was operating actively on all sides; and among the very first victims were persons who were accused of sorcery, and who were, of course, condemned. Such condemnations could not make the belief in the reality of the crime more unhesitating than it had been, but they had a direct tendency to multiply the accusations.' The state of insecurity and despair thus produced was heightened by the desolating effects of the Black Death, which, regarded as a direct chastisement for the sufferance of witchcraft, supplied a fresh incentive to still more frightful persecutions and massacres. The superstition which prompted these atrocities was not weakened by the advice of Luther, that a child reputed to be begotten by the devil should be thrown into a river; and Luther's convictions were shared by the most learned lawyers and judges of his age. If the multiplication of the most monstrous and impossible charges, and of testimony drawn from perjured accusers and tortured victims, could prove the reality of a conspiracy, the fact of a league between sorcerers and devils was proved beyond all reach of doubt; and the conviction that this fact was proved retained its hold on the mind of John Wesley, who declared that all belief in the Bible must stand or fall with belief in witchcraft. But the idea that this conspiracy was a well-attested fact, was a mere delusion. The nature of evidence was at that time most imperfectly known; and it has been said, not without justice, that the judicial processes of the middle ages exhibit little more than a tissue of prejudiced judgments based on a besotted credulity. The evidence of witnesses, whose perjury would now be self-evident, was received without hesitation, while the accused were supposed to speak the truth of themselves and their accomplices while under excruciating bodily torment. When at length the frantic excesses of the persecutors had roused some faint scepticism as to the reality of the crime, writers could be found to declare that, if such a crime had not been proved to exist, nothing existed; while lawyers and judges, not iniquitous in other matters, declared themselves profoundly satisfied with the evidence of knaves and fools. Thus when the executions in Italy had roused some sceptical opposition, Spina fiercely complained that men were not only refusing to believe what they ought to believe, but were exerting all their influence to obstruct those who were destroying the enemies of Christ. (Sprenger, *Malleus Maleficarum*, i. 460 &c.) This smouldering opposition betrayed itself in the treatise of John Wier, *De Præstigiis Dæmonum*. Wier, not questioning the existence of demons, sought to prove that all reputed cases of witchcraft were instances of direct possession, and that, as the intermediate agency of a witch was superfluous, the crusade against sorcerers and witches was unnecessary, and therefore cruel. The self-accusations of women he accounted for by 'the credulity and fragility of the female sex.' Yet Wier, who had not sought to limit the region of the supernatural, was stigmatised by Bodin (*Démonomanie des Sorciers*) as one who had armed himself against God and written a tissue of horrible blasphemies. The practical conclusions of Bodin were summarily rejected by Montaigne, who declared it to be quite unnecessary to believe evidence, even when it was impossible to explain it away. 'This is setting a high value on our opinions,' he said, 'to roast men alive on account of them.' Thirteen years later, Charron, in his treatise *On Wisdom*, systematised the scepticism of Montaigne; and it was in this interval that Boguet, presiding at the tribunal of St. Claude, is said to have burnt six hundred persons chiefly for lycanthropy. In England, the first protest was raised in 1584, by Reginald Scott, who, in his *Discovery of Witchcraft*, 'exposed the atrocious torments by which confessions were extorted, the laxity and injustice of the manner in which evidence was collected, the egregious absurdities that filled the writings of the inquisitors, the juggling tricks that were ascribed to the devil, and the childish folly of the magical charms.' So little effect had this protest in the prevailing temper of the age, that the zeal of James I. carried a law subjecting witches to death on the first conviction, even though they should have done no harm to their neighbours.

This law was passed when Coke was Attorney General, and Bacon a member of parliament. Later still, when a century had passed away from the time of Reginald Scott's protest, the sceptical Glanvil strenuously upheld the popular belief in witchcraft in his *Sadducismus Triumphatus*, and won the warm approval of Henry More, Casaubon, and Cudworth. Glanvil, employing a line of argument much in vogue at the present day, urged the credulity of unbelief as a reason for accepting the reality of witchcraft. 'Analysing with much acuteness à priori objections, he showed that they rested upon an unwarrantable confidence in our knowledge of the laws of the spirit world; that they implied the existence of some strict analogy between the faculties of men and of spirits; and that, as such analogy most probably did not exist, no reasoning based on the supposition could dispense men from examining the evidence.' This evidence appeared to him as conclusive as to Reginald Scott it appeared worthless, while he forgot apparently that, on his own hypothesis, he had first to prove the exist-

ence of spirits as well as their operation in the manner alleged. But while books continued to be written in favour of the belief, the belief itself among educated men was practically on the decline. Still, when at one of the latest trials, that of Jane Wenham, in 1712, the judge treated with disrespect the rector of the parish, who declared, 'on his faith as a clergyman,' that he believed the woman to be a witch, the jury convicted. The judge obtained a remission of the sentence; but the clergy who had been her accusers vehemently reiterated their belief, and ended their protest with the words 'Liberavimus animas nostras.'

In Scotland the belief in witchcraft was more obstinate, and the horrors of witch persecutions perhaps reach their culminating point in the country where John Knox shaped the Reformation. 'As late as 1773 the divines of the Associated Presbytery passed a resolution declaring their belief in witchcraft, and deploring the scepticism that was general.' (Lecky's *History of Rationalism*, ch. i.; for the part taken by the clergy in fostering this superstition, see Buckle, *History of Civilization in England*, vol. iii. ch. ii.) The last victim capitally sentenced was put to death in 1722; but the practice lingered to a later time in some continental districts, as in Catholic Germany, Spain, and Switzerland. The subprioress of a convent was burnt at Würzburg in 1749; and the last, probably, of all the victims of this superstition, Anna Göldi, a domestic servant, was burnt at Glarus, in Switzerland, in 1782. A painstaking collection of learning on this strange subject will be found in Horst's *Zauber-Bibliothek*. (Grimm's *Deutsche Mythologie*, passim; Michelet, *La Torture*.)

Witches' Besoms. A name given to the bunches of branches altered from their original form, which are developed on the Silver Fir in consequence of the attack of a minute fungus, called *Peridermium elatinum*. The leaves as well as branches are altered in form from their first appearance, and soon fall, a new crop of infested foliage being produced each year from the buds. The fungus is apparently confined to the besoms.

Witches' Butter. The vulgar name of *Exidia glandulosa*, a dark brown or black jelly-like fungus studded above with little glandular points, and below rough like crape.

Witena-gemot (A.-Sax.). The great national council of the Anglo-Saxon nation, probably the direct representative of the popular assemblies of which Tacitus (*Germ.* xi.) speaks as existing among the old German tribes; the *folkmot*, or meeting of the whole tribe or nation, having in a larger territory and among a more scattered population become converted by a natural process into the *witena-gemot* or meeting of councillors. The meetings of the witan appear to have been attended by the king, by prelates and abbots, and sometimes by inferior clergy, by dukes and ealdormen, by milites ministri or thanes, many of whom were no doubt reeves or other royal officers in the shires. The witan was convened by the king either pro hâc vice or generally. Many acts or charters passed at its meetings are extant, and bear signatures (often from 90 to 100 in number), which may be assumed to be those of the members of the witan present, and which in fact form a principal source of our information on the subject. The witan, though not elective in the modern sense, was considered as representing the whole body of the people; but it is probable that the freemen in the neighbourhood were allowed to be present at its meetings, and exercised at least a right of assent to its decisions. According to Mr. Kemble, the witan (1) possessed a consultative voice and right to consider every public act which could be authorised by the king; (2) deliberated upon new laws, which were then promulgated by their authority and that of the king; (3) had the power of making alliances and treaties of peace, and of settling their terms; (4) had the power of electing the king; (5) had power to depose the king if his government was not conducted for the benefit of his people; (6) had, with the king, power to appoint prelates to vacant sees; (7) had power to regulate ecclesiastical matters generally; (8) had, with the king, power to levy taxes for the public service; (9) had, with the king, power to raise land and sea forces; (10) had the power of recommending, assenting to, and guaranteeing grants of lands; (11) had the power of adjudging the lands of offenders and intestates to be forfeit to the king; (12) acted as a supreme court of justice both in civil and criminal cases. (Kemble, *Saxons in England*.)

Withamite. A variety of Manganesian Epidote discovered by Witham, both massive and in minute but brilliant and transparent carmine-red crystals, lining small cavities in trap-rock, at Glencoe, in Argyleshire. It is a ferro-silicate of alumina.

Witherite. Native carbonate of baryta, named in honour of Dr. Withering, who first discovered it at Anglezarke, in Lancashire. It occurs amorphous and in six-sided crystals, resembling the common form of Quartz, and generally white, but sometimes of a greyish or greenish colour, at Alston Moor in Cumberland, Fallowfield in Northumberland, Dufton Fells in Westmoreland, &c.

Witherite is used in the manufacture of glass and china, and also in France in the manufacture of beet-root sugar.

Withershins. In the witchcraft of Scotland, this word (the German wiederschein) was used to denote the wrong or unlucky way of going round a person who was to be restored from sickness. The leech made the circuit, or dessil, round the couch of the sick man three times, moving from east to west, according to the course of the sun. To go round in the opposite direction was considered unpropitious.

Witness (A.-Sax. witnesse). In Law, one who gives evidence in a judicial proceeding.

In civil cases, witnesses are compelled to attend by the process called SUBPŒNA AD TESTIFICANDUM, and punishable, if they neglect to do so, by attachment or action. In criminal cases, the process is by subpœna or by recognisance taken by the magistrate before whom the information is given. [EVIDENCE.]

Wizard (akin to *wise* and *witch*). The popular name in England for a sorcerer. [WITCHCRAFT.]

Woad (A.-Sax. wad). The *Isatis tinctoria*, a plant which yields by the fermentation of its leaves a blue colouring matter resembling indigo. It is the *Pastel* of the French.

Woden. In Mythology, another form of the name of the Norse god ODIN, who with THOR stands at the head of the Teutonic pantheon. The name Thor appears in the forms Thunor (as in the A.-Sax. Thunres-dæg, *Thursday*), and Donner, *thunder*. His *hammer* seems to be the same word as the Greek Acmon, the Slavonic form of *hamar* being Kamen, and the Lithuanian akmu, akmens. (Bréal, *Hercule et Cacus*, 141.) The name *Woden* is preserved in the English Wednesday.

Wöhlerite. A columbate of zirconia, with silicate of lime and silicate of soda, found embedded in the zircon-syenite of Norway in crystals of various tints of yellow, inclining to red, brown, or grey. Named after Wöhler, the eminent chemist.

Wölchite. An arsenio-sulphide of lead, copper, and antimony, found in short rhombic prisms of a blackish lead-grey colour, in the iron-mines at Wölch, in the Lavant Valley, in Carinthia.

Wolf Fish. The name of a species of fish (*Anarrhichas lupus*, Linn.), which subsists on whelks and other shell-fish. It seizes its prey by means of strong conical slightly curved anterior teeth, set in the jaws like grappling hooks, and bruises by the action of very powerful posterior molar teeth.

Wolfram. Native tungstate of protoxide of iron, met with in the primary rocks of Cornwall, Saxony, and other countries, frequently associated with tin-ore. It occurs both massive and crystallised, of a dark-greyish or brownish black colour, with a brilliant (often metallic) lustre, and is sometimes feebly magnetic.

Tungsten is used for the manufacture of tungstate of soda, which affords a mordant in dyeing, gives hardness to plaster of Paris, and is the best material for rendering dresses incombustible. Added to steel, it possesses the property of imparting a degree of hardness to the alloy far greater than can be given to the metal when used alone. The name Wolfram (from Ger. wolferig, *eating*) has reference to the smaller quantity of tin obtained from the ores in which it is present.

Wolframium. [TUNGSTEN.]

Wolfsbane. The popular name of the *Aconite*, which is also called *Monkshood* from the shape of its flowers. In sufficient doses it is virulently poisonous, its most characteristic effects being the production of tingling and numbness, vomiting, contracted pupil, failure of the circulation, and occasional convulsion. Fatal results have sometimes occurred from mistaking this root for horseradish, to which, however, it bears little resemblance. It has been medicinally used with great success in some obstinate cases of *tic douloureux*, or *neuralgia*. Its powers are ascribed to the presence of the alkaloid *Aconita*. [ACONITE.]

Wollastonite or **Tabular Spar.** A silicate of lime which occurs generally in broad prismatic or laminar masses, but sometimes in distinct tabular prisms, from which it has derived the common name of Table or Tabular Spar. It is met with in white fibrous masses at Dunmore Head, county Down; at Glengairn, in Aberdeenshire; and in the basalt of the Castle Rock, Edinburgh. Named after Dr. Wollaston.

Women, Condition of. The social position occupied by women varies not only as communities are civilised or barbarous, but in communities which have reached the same point of civilisation. Nor is the respect felt for women to be measured always by race, for tribes or subdivisions of the same race give their women very different privileges and award them very different degrees of consideration. Race, however, is, on the whole, the chief cause for variety. Thus, among the negro and Malayan races, women are generally enslaved, perform all the hard labour of the field and the household, and are looked on as drudges. Among Semitic tribes, on the other hand, the women are secluded, and condemned to idleness and privacy, whenever the husband's wealth enables him to establish a harem; and even among persons of poorer condition, women are as far as possible concealed from public view. Among nations of Aryan origin, on the other hand, women are treated with respect, sometimes with great tenderness and honour.

In the earliest pictures of social life which we possess, the sacred books of the Jews, the Homeric poems, and the Hindu vedas, women appear to have held a far higher social position and to have had far more personal freedom than they afterwards enjoyed in the same countries or among the same people. The whole course of Jewish history indicates a very different position for the women of the people than that of the inmates of a harem or zenana, jealously closed and carefully guarded.

So again with the domestic life of the Greeks. The picture of the faithful Penelope, importuned by a number of suitors for her hand, vexed at their effrontery and riot, but never insulted or threatened; the loves of Hector and Andromache; the chivalrous sentiment felt towards Helen, though the author of so many griefs to Troy, point to a different social condition from that with which we are familiar in later times, when at Athens a woman's best reputation was to have no fame either for good or evil (Thucyd. ii. 45), when the education of women was discouraged lest they should

rebel against the authority of their masters, and when they were shut up in the inner part of the house, in all but Oriental seclusion.

The early literature of the Hindus gives similar testimony as to the equality of the sexes. A striking illustration of this equality may be found in Prof. Max Müller's *Ancient Sanskrit Literature*, p. 22, where a wife asks her husband what are the means by which she might reach that perfection which formed the chief object of those who strove to the honours of Brahmanical saintship, and expresses her conviction that conjugal love may be the means to this end. Her husband, who has just resolved to quit his home in order to devote himself to a life of contemplation, seeks to disabuse her of this impression, and says that 'a husband is loved, not because you love the husband, but because you love in him the Divine Spirit; a wife is loved, not because we love the wife, but because we love in her the Divine Spirit; children are loved, not because we love the children, but because we love the Divine Spirit in them.' And the speaker goes on to state that the course towards perfection is the same both for women and men, in strong contrast to the language used by the later sacred writings, in which women are treated as inferior, are precluded from any partnership in the family sacrifices, are forbidden to read the Vedas, or to assume the right of judgment on sacred things. A similar tenderness towards women is to be found in the early romantic dramas of the Hindus, such as the Sacontala.

The condition of women in ancient Rome was peculiar. The head of the house was the centre of all power and authority. The father had the right of life and death over his children, even after they were married and had households of their own. There was no escape from this authority, unless the son were thrice formally emancipated before the prætor. A married woman was greatly in the power of her husband and male relations, who could punish her with death for certain offences. But such a power did not accrue to the husband, unless the marriage took place in the solemn form called *confarreatio*. Hence, in course of time, as women were made independent, this solemn marriage became more and more rare, and at last was almost disused. The facilities of divorce, the licentiousness of the wealthy Roman matrons, and the general dissoluteness of Roman social life, are well known.

It was, however, among the German tribes that the greatest respect was paid to women. This fact was known to Tacitus, and commented on by him, for he speaks of these tribes as looking on women as possessed of a sort of inspiration. Of similar character also was the respect paid to their women by the Anglo-Saxons.

It is not easy to trace the origin of that chivalrous devotion towards women which constituted one of the best traits of the knightly character, and of that gallantry which ensued from the feeling. It was no doubt partly derived from the habits of race; it was probably increased by the quasi-religious character which belonged to most orders of knighthood. It became possibly still stronger by the contrast in which it stood to the treatment shown to women on the part of the Mohammedans, and which must have been taken note of in the time of the Crusades. For it is especially among Mohammedan nations, and in India among such communities as have imitated the social system without the faith of Islam, that the social position of women is the lowest, except, of course, among negro tribes.

Mr. Mill has of late years argued strongly that women should be, as far as regards the suffrage, on an equality with men. [REPRESENTATION.] It is singular that when the reformed mutineers of the Bounty established a constitution for their small settlement, they gave the suffrage to all adults, without distinction of sex, in the annual election of their chief magistrate. The rights which by English law a husband and wife have in each other's property, and the usual manner in which those rights are modified by agreement, are fully explained under MARRIAGE and SETTLEMENT.

For some singular customs attaching to women, and for regulations, intended, it would seem, on some occasions, to protect them, see Mr. E. B. Tylor's *Researches into the Primitive History of Mankind*, see also the treatise of Cornelius Agrippa, *De Excellentia Fœminini Sexus*.

Wonder-earth. [TERATOLITE.]

Wood (A.-Sax. wuda, Dutch woud). The solid part of the stems and branches of a plant, as distinguished from the pith which occupies the centre, and the bark which envelopes the whole. The wood of most trees, i.e. of all exogens, is formed in annual layers deposited below the bark, but on the exterior of the wood of previous growth. It consists of fibrous matter, called *woody tissues*, formed during the growth of the plant. Thus, when a seed germinates, and the plumule has become developed, it begins at once to send down fibres into the centre of the radicle, and these fibres constitute the first rudimentary wood. As leaves form and come into use, more perfect descending fibres are developed, these forming a cylinder of alburnum between the medullary sheath [MEDULLARY SHEATH] and the bark, and in this way, by the end of the first season of growth, there is formed a woody axis, surrounding the pith, and enclosed by the bark. The growth of the wood of a timber-tree is but a repetition of this process year after year.

It has been observed that wood is formed in annual layers, which layers, though not separable from each other, are seen in the grain of the wood when cut, so that by counting the rings of wood in the trunk of an exogenous tree, its age may be pretty clearly ascertained. In the accompanying figure, these layers are distinctly visible. The pith is shown at *a*, and the bark at *b*, while *d e* and *f* represent three

distinct layers of wood. In the end section the medullary rays [MEDULLARY RAYS] are evident, radiating from the centre outwards. The first year there is the pith, bark, and one ring of the wood formed (*a*, *b*, *d*). The second year new matter is deposited between the bark and the wood already formed; this consists of a viscous mass called *cambium*, which is gradually organised, and separates into two parts, the one forming an addition to the wood, the other to the bark. The third year new matter is again similarly interposed, while the old bark is pushed out and ruptured, and is gradually replaced by the new layers.

At the age of a few years wood acquires a different colour from that which it first possessed. It is then called *Heartwood* or *Duramen*. In the Beech, this is light brown; in the Oak, deep brown; in Brazil-wood and Guaiacum, green; and in Ebony, black. In all these it was at first colourless, and it owes its different tints to matter deposited gradually throughout its tissues. That part in which no such colouring matter is yet deposited, the portion exterior to the heartwood, is called *Sapwood* or *Alburnum*.

The wood of endogens differs from that of exogens in not being formed in concentric layers. It has no distinction of pith, wood, and bark, nor any medullary rays, and consists of bundles of woody fibres, dispersed irregularly among a mass of lengthened cellular tissue, the bundles being more crowded towards the circumference.

The value of wood, in the constructive arts, depends upon the toughness and cohesion or compactness of its tissues, that which has been most quickly grown being, cæteris paribus, of the best quality. The different colours, smell, and taste of different kinds of woods, are imparted by their peculiar resinous, gummy, or oily secretions. The colouring matter is sometimes deposited in such abundance as to render it useful for dyeing, as in the Logwood. Some woods have deposited in them volatile oils, which render them odoriferous, as in the Sandalwood; and bitter and other secretions give them a medicinal value, as in the Quassia.

Wood Coal. A synonym of BROWN COAL, and also of Cannel Coal.

Wood Engraving. [ENGRAVING.]

Wood Opal. A variety of Opal with a peculiar ligneous structure, which is made into snuff-boxes and other ornamental articles, at Vienna. (Bristow's *Glossary of Mineralogy*, p. 411.)

Wood Spirit. Crude wood spirit is now mixed by the excise to the extent of ten per cent. with alcohol; and the mixture, under the name of *methylated spirit*, is then allowed to be sold free of duty. [PYROXYLIC SPIRIT.]

Wood Stone. Petrified or mineralised wood. [WOOD OPAL.]

Wood Tin. Fibrous oxide of tin. An opaque, fibrous, and nodular variety of Cassiterite or Tin-stone, of a brown colour, and presenting a ligniform appearance, which is met with only in a few Cornish mines and in some of the principal stream-works of that county.

Woodbine. The Honeysuckle, *Caprifolium Periclymenum*.

Wooden Bottoms. [SABÔT.]

Woodlock. A block of wood nailed on each side of a ship's rudder to prevent it from being lifted off its hinges and unshipped.

Woodroof. The common name for the fragrant *Asperula odorata*, sometimes called Woodrow or Woodruff.

Woody Fibre. In Vegetable Physiology, the name given to very slender transparent membranous tubes, tapering acutely to each end, lying in bundles in the tissue of plants, and having no direct communication with each other. They are of extreme tenuity, and form the substances called *hemp* and *flax*. The same tissue forms wood.

Wool (A.-Sax. wul). In Commercial language, this term is applied to the hair of the alpaca, the goat, the beaver, the rabbit, and to similar substances, for weaving or felting; but strictly it belongs to the sheep only, the hair of which has, from time immemorial, been woven into cloth. According to Thucydides, however (book i.), the use of woollen garments was subsequent, in Athens, to that of linen. But woollen clothing is frequently mentioned in the Homeric poems.

In the middle ages, and especially in the thirteenth and fourteenth centuries, the best wool was produced in this country, part being exported to the Netherlands, part consumed in the home manufactures, the seat of which was at that time principally Norfolk, though cloths were woven in the West of England and in Ireland. The wool was of very different qualities, the best coming from Shropshire and Derbyshire, the worst from the mountain pastures of Westmoreland, and from the South Downs. It is probable that the great excellence and abundance of the English wool was in the main due to the comparative effectiveness of the police of this country, or, as it was styled, to the maintenance of the king's peace. As a sheep is of all animals the most defenceless, and on the whole the most eatable, it was difficult to rear flocks during those times of feudal anarchy in which France and Germany were ravaged by the companies and the Rhenish barons. At any rate, existing specimens of mediæval cloth, of the date of which there can be no doubt, do not indicate a very high quality in the wool of which they are composed.

The export of English wool was so important a matter to the Flemish manufacturers, that the foreign policy of the two countries during the fourteenth and fifteenth centuries was mainly determined by the wool trade. The supply of English wool drew James Arteveldt into his alliance with Edward III. The prosperity of Flemish manufactures was the object which in great measure determined the policy of the duke of Burgundy in the beginning of the fifteenth century. The risk of checking this prosperity put a stop to the intrigues of Mary, duchess of Burgundy, at the conclusion of the same period. Concurrently with these foreign relations, the English government strove, and with some success, to encourage a home manufacture, and therefore occasionally prohibited the export, or regulated it, or fixed the price of the article, or defined the places at which it should be sold. So important was the produce that it frequently formed the material of a tax; and the grant of some thousands of sacks, or a tithe of fleeces, was a familiar subsidy. The taxes levied on this principle give us an insight into the distribution of wealth in England; and the licenses to export denote generally the value of the produce in different localities. [TREATY, COMMERCIAL.]

English sheep are said to have been exported to Spain—the date for the transaction is not to be found—in pursuance of a treaty, and in exchange for Spanish horses. It is stated that this flock was the origin of the merino wool, for which Spain was so famous. At the beginning of the present century, some of the descendants of these sheep were taken to Germany, and produced the fine wools of Saxony. The belief, however, in the vast superiority of English wool, induced the legislature to place heavy restrictions on its exportation, and to continue these by penalties made increasingly severe, and ultimately capital, long after this superiority had passed away. It was only in 1825 that the prohibition laid on the exportation of British wool was abolished, abundant evidence being given that the English manufacturer made no gain by the prohibition, and that the agriculturist suffered a serious loss.

No duty was levied on foreign wool up to the year 1802, when it was subjected to a tax of 5*s.* 3*d.* per cwt. The tax was raised to 6*s.* 8*d.* in 1812, and increased by Mr. Vansittart, whose name is to be identified with every conceivable folly in finance, to 56*s.* per cwt., i.e. 6*d.* per lb. Fortunately his policy was reversed by Mr. Huskisson in 1825, when colonial wool was made free, and foreign wool subjected to an ad valorem duty of 1*d.* if worth more than 1*s.* the lb., or ½*d.* if less. In 1840 foreign wool was freed from duty.

Excellence in wool is seldom attained concurrently with excellence in the flesh of the sheep, and thus improvements in the herd are fatal to the fineness of the fleece, to the softness of the hair, and the length of the fibre. Nor is the climate of this country so favourable to the growth of the best wools as that which is hotter and drier. Hence the superiority of merino, Saxony, and finally Australian wools. Up to the time in which the elector, afterwards the king of Saxony, developed the produce of wool in his dominions, Spanish wool was the best; but after the introduction of Saxony wool, the Spanish imports rapidly declined. Since the introduction of sheep farming on an extensive scale in Australia, the Saxony produce has undergone a similar fate. Latterly, the employment, and consequently the production, of wool has received a powerful stimulus by the comparative scarcity of cotton. (*Commercial Dictionary.*)

The various processes of the woollen manufacture, as at present carried on, are more numerous and complex than those of any other of our textile manufactures; but our limits do not allow us to specify them.

Many methods of cheapening woollen cloths have been introduced. [MUNGO; SHODDY.] Among these may be mentioned the use of cotton warps with woollen woofs. Cloths with cotton warps are generally called *union cloths.*

Mr. Baines' Estimates of the Annual Value of the Woollen Manufacture of the United Kingdom, 1858.

(1) Raw material—		
lbs.		£
75,903,666	foreign and colonial wool .	4,717,492
80,000,000	British wool at 1*s.* 3*d.* per lb.	5,000,000
	Shoddy and Mungo—	
45,000,000	{ 30,000,000 lbs. shoddy at 2½*d.* per lb. . . . . 15,000,000 lbs. mungo at 4½*d.* per lb. . . . . }	609,370
	Cotton and cotton warps, $\frac{1}{10}$ of the wool	206,537
200,903,666		£10,533,399
(2) Dye-wares and soap		1,500,000
(3) Wages—150,000 work-people at 12*s.* 6*d.* per week		4,875,000
(4) Rent, wear and tear of machinery, repairs, coal, interest on capital, and profit—20 per cent. on the above		3,381,680
	Total	£20,290,079

Woollen Manufacture, Middle Ages.—The chief seat of the woollen manufacture of England 500 years ago was Norfolk, especially at the towns of Norwich, Aylesham, and Lynn. It is probable, however, that the art of weaving was general over the whole county, for it appears that Norfolk was by far the wealthiest of the English counties at the time referred to. (Rogers, *Agriculture and Prices in England.*) The art of weaving was either brought into England, or at least improved, by the Flemings, between whom and the inhabitants of the eastern English counties close commercial relations subsisted. The fact of these relations will explain the political alliances between the English sovereigns and the weavers of Bruges, Liège, and Ghent.

Certain specimens of early English cloth may yet be seen. New College in Oxford still possesses the mitre case of the founder, a strong wooden box covered with leather, banded with iron, and lined with stout cloth; but the

wool is coarse and full of hairs, and the texture of the cloth is rude. The high market price of English wool was owing, doubtless, to the absence of such security on the Continent as was necessary for the raising of sheep. The greatest care was taken to secure, by means of a police [ULNAGE], that imported cloth should come up to the standard of length and breadth.

The chief mart of English and foreign cloth was Stourbridge fair, which was held in a field about two miles from Cambridge, and lasted about a month. This fair was to the mediæval Englishman as important as that of Novgorod or Leipsic to the Russian and German.

Woold. In Naval language, to strengthen a made or started spar, by winding tarred rope tightly round it at the weak or suspected place.

Woolsack. The seat of the Lord Chancellor, in the House of Lords, is said to be so called from its having originally been a large square bag of wool without back or arms. There can be no doubt, at all events, that the ancient name represents the great importance of the wool trade of the middle ages.

Wootz. A species of steel of excellent quality, imported from India, and of which it is believed that the celebrated Damascus sword blades were made. It is made by melting small pieces of wrought iron mixed with some twigs from a tree and covered by a green leaf in small crucibles luted close with clay; these crucibles are then built up in a pyramidal form in a furnace and exposed to a strong heat. The pieces of wootz are taken out after the crucibles have cooled, and are of the size of about half a hen's egg. To form a Damascus sword blade, each piece of wootz was drawn out under the hammer into a thin riband, and a bundle of these was then welded together. Woots has been known from a remote antiquity. It contains traces of silicium and aluminium.

Words (A.-Sax. wyrd; Ger. wort, from werden, *to become*). In Language, the names assigned to conceptions or phenomena. According to the realistic doctrine, words were things, and the existence of a word implied not merely the existence of a conception, but the existence of an object answering to that conception. This notion underlies the Aristotelian dictum *de omni et nullo* [LOGIC]; its practical effects are noticed in the articles PROPOSITION and SYLLOGISM. The analysis of LANGUAGE shows that all abstract terms, denoting intellectual or transcendental ideas, are derived by METAPHOR from words originally expressive only of animal or bodily sensations. The so-called UNIVERSALS are thus mere labels or tickets, for the more convenient arrangement of our observations of phenomena; and such a term as *humanity* is merely a name for all men collectively, and must not be taken as implying the existence of any abstract thing or essence existing out of or apart from all individual men. The same may be said of such words as Virtue, Justice, Truth, and other like terms. For the origin of names, the reader is referred to the articles ROOTS, POLYONYMY, and SYNONYMY; and for their influence in the formation of religious ideas, to THEOLOGY, VRITRA, WERE-WOLVES, WITCHCRAFT, &c.

Work (A.-Sax. weorc, Ger. werk, Gr. ἔργον). In Mechanics, the work performed by any force is measured by the product of the force into the space through which it is exerted. In Britain the *unit of work* is called the *foot-pound*, and is that which is performed in raising a pound weight, in opposition to gravity, to a height of one foot. The work required to raise five pounds to a height of ten feet, therefore, is fifty *foot-pounds*.

World (A.-Sax. werrold, Swed. verld). A name sometimes used to denote the earth, and sometimes the whole cosmos. The ancient myths on the origin of the world are noticed in the article THEOGONY, while the philosophical theories of the earliest philosophers on the same subject are sketched in the articles ELEATIC PHILOSOPHY, IONIAN PHILOSOPHY, and PYTHAGOREANS. All these theories, like the astronomical science of the Greeks, are deductive in character, and start with some arbitrary hypothesis with which observed phenomena must be made to harmonise. A summary of the results obtained by inductive observations of phenomena is given in Humboldt's *Cosmos*. For the physical systems of mediæval thinkers, see Hallam, *Middle Ages*, part ii. ch. iii.

Worm Bark. The bark of the *Andira inermis*, or *Cabbage bark tree*, of the West Indies. It is cathartic, emetic, and narcotic, in doses of from twenty to thirty grains. It is usually given in the form of decoction.

Worm Seed. The substance sold under this name, or that of *Semen contra*, consists of broken peduncles, mixed with the calyces and flower buds of some species of *Artemisia*, and is not the seed of *Artemisia Santonica*, as usually represented. Worm seed is imported from the Levant, and used as a vermifuge in doses from ten to thirty grains. This name is also applied to *Ambrina anthelmintica*, *Erysimum cheiranthoides*, *Artemisia Vahliana*, and *A. judaica*. [SANTONIN.]

Worm Tea. A preparation kept in the shops of the United States, and much used: it consists of spigelia root, savine, senna, and manna.

Wormia (after Olaus Wormius, a Danish naturalist). One of the species of this genus of *Dilleniaceæ*, *W. excelsa*, is a very large forest-tree, native of Java and the Malayan Peninsula, where it is called Kayu Sipur by the Malays, and is valued for its excellent timber, which bears some resemblance to oak.

Wormwood. The *Artemisia Absinthium*, a composite shrub, containing a peculiar bitter principle, called *Absinthine*, to which its medical virtues may be ascribed. Its infusion was formerly a favourite popular remedy for worms, but it is now disused. A liqueur flavoured by wormwood is in great repute in France, under the name of *Crême d'absinthe*.

Wort (A.-Sax. wyrt; Ger. wurz, *a herb*). A plant or herb. The word was formerly used in a general sense, but is now chiefly employed in compounds, as Spleenwort, Woundwort, Mugwort, &c.

Woulfe's Apparatus. A series of two or three necked bottles, connected by intermediate tubes, used in the chemical laboratory for impregnating water and other liquids with various gases or vapours. It is also a convenient form of apparatus for the generation of gases where the assistance of heat is not required.

Wound Balsam. The compound tincture of *Benzoin* of the *Pharmacopœia*, known also as *Friar's Balsam.*

Wourali or **Wourara.** The Woorari, Ourari, or Urari, an arrow-poison prepared by the South American Indians, from *Strychnos toxifera.* [OURALI; STRYCHNOS.]

Wrack (Fr. varech). The *Zostera marina*, a common weed of the sea, though not belonging to the sea-weed family (*Algæ*), is the Sea Wrack, or Grass Wrack. It has been referred to the *Naiadaceæ*, but is sometimes regarded as the type of an order *Zosteraceæ*. Its long grass-like leaves are collected for packing, and for stuffing mattresses, under the name of *Ulva marina*. The term *Wrack* is also applied to sea-weed generally when thrown ashore. This wrack is collected by farmers who cultivate coast land, and is used as a manure.

Wrangler. At Cambridge, those who attain the highest honours in the public mathematical examinations for the degree of bachelor of arts are so called. At the close of the last day of examination, those who have most distinguished themselves (to the number of thirty at least) are arranged in order of merit by the examiners, and divided into three classes: wranglers, senior optimes, and junior optimes. The first or senior wrangler is the most distinguished mathematician of his year. The name is probably derived from the public disputations in which candidates for degrees were formerly required to exhibit their powers.

Wrecks (A.-Sax. wræc, akin to Lat. frango, freg-i; Gr. ῥήγνυμι; Ger. brechen, *to break*). Goods cast up by the sea after a shipwreck, and left on land within the limits of some county. The goods so brought to land belong at common law to the king, or to the lord of the manor enjoying the franchise of wreck. It was ordained by Henry I. and Henry II. that such forfeiture should not take place if any man or beast escaped alive from the wreck; and we find in Bracton (Henry III.) that in his time if the goods could be known by marks to appertain to any owner, it was no wreck, even if no living creature escaped. The limitation of claims by the owner, by stat. West. 1 (3 Edw. I.), was within a year and a day. The Board of Trade now appoints receivers of wreck, who are to keep the goods a year; if not claimed within that time they go to the crown. (See Merchant Shipping Act of 1854, and amending Act.) Plundering wrecked vessels or goods stranded is felony. Goods cast overboard at sea, and not stranded, are divided into JETSAM, i.e. things sunk to the bottom; FLOTSAM, things found floating; and *ligsam*, things sunk, but fastened to a buoy or cork in order to be found again. These do not pass by the ordinary grant of wreck, but are expressly included in the statutory jurisdiction of the Board of Trade.

Wreckers. A name commonly applied to persons who make it their business to pillage shipwrecked vessels. In the Bahamas, the *wreckers* are vessels licensed by government to succour ships in distress, and they are allowed a salvage on the property recovered by them.

Wrestling (A.-Sax. wræstlian, *to struggle*). This practice of wrestling answers to the Greek πάλη, in which the wrestler had to throw his adversary either by swinging him round or tripping him up. [TEUTONIC.]

Wrightia (after Dr. W. Wright, a Scotch physician). A genus of *Apocynaceæ*, consisting of shrubs, or small, sometimes scandent and aërial rooting trees, confined to the eastern hemisphere, ranging from Silhet and Nepal to Western Australia. An inferior kind of indigo is prepared from the leaves of *W. tinctoria* in some parts of Southern India, and called Pala Indigo, from Pala or Palay, the Tamil name for this and some allied milky trees. The wood of the Palay is beautifully white, close-grained and ivory-like, and is commonly used in India for making toys. It is well suited for turning, carving, and inlaying, and has been tried for engraving as a substitute for boxwood, but found unsuitable. The wood of *W. antidysenterica* has also been made the subject of a similar experiment without success. It is very hard in centre, and is used in India for posts and rice-beaters. The bark is the Conessi-bark of the *Materia Medica*, and is valued as a tonic and febrifuge, and as a remedy for dysentery. The oat-like seeds also are reputed to possess valuable medicinal properties.

Wrist Drop. A disease to which compositors are liable, caused by using new type, which cuts the skin of the thumb and fingers. Lead poison enters at the abraded places, and paralysis of the wrist is the result. It may be cured by soaking the hand in a solution of potassium, and eliminating the lead.

Writ (A.-Sax. writan, to *engrave*). In Law, a precept in writing under seal, in the name of the king, judge, or any other person having jurisdiction in the particular subject-matter, and directed to some public officer or private person, requiring him to do something in relation to a suit or action, or otherwise.

Writers to the Signet. A society of lawyers in Scotland, equivalent to the highest class of attorneys in England. [SIGNET.]

Writing. [ALPHABET; CUNEIFORM LETTERS; PAPER.]

Wryneck. A permanent inclination of the head towards one of the shoulders, not necessarily connected with distorted vertebræ, but arising mostly from a contraction of the

sterno-cleido-mastoideus muscle. This is often a spasmodic affection, and connected with nervous lesion.

WRYNECK. The *Yunx torquilla*, a common English scansorial bird, observed in spring.

Wulfenite. A name for the native molybdate of lead, after the Austrian metallurgist, Wulfen. It occurs crystallised and massive, generally of an orange or wax-yellow colour passing into grey, green, or brown, in Dauphiny, Carinthia, Hungary, Saxony, &c.

Wuotan. [WODEN.]

Wyvern. In Heraldry, an imaginary animal resembling a flying serpent.

X

X. A letter borrowed from the Greek, and used chiefly in words derived from that language. As a Roman numeral, it denotes 10.

Xanthein (Gr. ξανθός, *yellow*). The yellow colouring matter of flowers.

Xanthic Acid (Gr. ξανθός). *Sulphocarbethylic acid.* An acid composed of sulphur, carbon, hydrogen, and oxygen, and obtained in combination with potassa by agitating bisulphuret of carbon mixed with solution of pure potassa in strong alcohol. Its compounds are of a yellow colour, whence its name. Its atomic composition has been represented as $HO,C_6H_5OS_4$.

Xanthic Oxide. A yellow substance found by Dr. Marcet in a urinary calculus; its solution in nitric acid, when evaporated to dryness, left a bright lemon-coloured residue. Its composition is $C_{10}H_4N_4O_4$.

Xanthin (Gr. ξανθός). The yellow colouring principle of madder.

Xanthite (Gr. ξανθός). A variety of Idocrase found in small rounded grains or imperfect crystals of a yellow or greyish colour, at Amity in New York: its principal constituents are silicate of alumina and silicate of lime.

Xanthochymus (Gr. ξανθός, and χυμός, *juice*). This genus of arboreous *Clusiaceæ*, which is named in allusion to the yellow resinous juice which exudes from their trunks, consists of three tropical Asiatic species. *X. ovalifolia* is confined to Ceylon, and was at one time supposed to be the tree which afforded the Gamboge of that island; but this is now known to be the produce of *Garcinia Morella*, the juice of *X. ovalifolia* being valueless. *X. pictorius*, a native of the mountains of Northern India, and *X. dulcis*, found in the islands of the Indian Archipelago, both yield edible pleasant-tasted fruits about as large as apricots, of a beautiful bright shining yellow colour, of a nearly globular form.

Xanthocone (Gr. ξανθός, and κόνις, *dust*). An arsenio-sulphide of silver found in very thin six-sided tabular crystals, but generally in small crystalline kidney-form masses at the Himmelfürst Mine, near Freiberg, in Saxony. It is of a dull-red or clove-brown colour, but affords a yellow powder (whence the name).

Xanthophyll (Gr. ξανθός, and φύλλον, *a leaf*). The yellow autumnal colouring matter of leaves.

Xanthophyllite. A variety of Clintonite found in implanted globules and in foliated crystalline individuals in the talcose slate of the Schischimskian Mountains of the Ural. It is a combination of silicate of alumina with silicate of magnesia.

Xanthopicrin or **Xanthopicrite** (Gr. ξανθός, and πικρός, *bitter*). A crystalline bitter principle contained in the bark of the *Xanthoxylon caribæum*, which is used in the Antilles as a febrifuge. It forms yellow acicular crystals, insoluble in ether, but readily soluble in alcohol, and sparingly in water.

Xanthoprotein (a word coined from Gr. ξανθός, and πρωτεῖον, *the chief rank*). A yellow acid substance formed by the action of nitric acid upon fibrine.

Xanthorhamnin (Gr. ξανθός, and ῥάμνος, *a prickly shrub*). A yellow substance extracted from the berries of *Rhamnus tinctoria*, the *Persian berries* of commerce. It contains $C_{23}H_{12}O_{14}$.

Xanthorrhiza (Gr. ξανθός, and ῥίζα, *a root*). A genus of *Ranunculaceæ*, represented by an undershrub, *X. apiifolia*, inhabiting the Southern States of North America. The name is given to this plant from its long roots and rootstocks, which are of a bright-yellow colour; whence also it is commonly called Yellow-root in the United States. Its inner bark wood and pith are also of the same colour. The whole plant was formerly employed by the American aborigines for dyeing yellow; and the American physicians of the present day use it medicinally as a tonic, all parts of it having a purely and intensely bitter taste.

Xanthorrhœa (Gr. ξανθός, and ῥέω, *to flow*). The genus of *Liliaceæ* to which belong the Black-boy or Grass Gum trees of the Australian colonies, most of the species of which have thick trunks like those of palms, covered with a dense coating formed of the persistent bases of old leaves glued together by the yellow or red resin with which these plants abound, and usually burnt and blackened outside by bush-fires. Their leaves are long, wiry, and grass like, and are borne in a dense tuft at the top of the stem, and hang down gracefully all round it; their long flower-stalks rising out of the centre, and sometimes growing as high as fifteen or twenty feet, bearing at the top a dense cylindrical flower-spike.

The tall-growing species, *X. arborea*, *X. hastilis*, &c. form a conspicuous feature in

some Australian landscapes; and when denuded of leaves have been compared to or even mistaken for black men holding spears, hence their common colonial name. Their leaves afford good fodder for cattle, while the natives eat the tender white centre of the top of the stem. Two kinds of fragrant resin —one of a yellow colour, called Botany Bay or Acaroid resin, and the other red like Dragon's Blood, and called Black-boy Gum—are obtained from them.

Xanthorthite (Gr. ξανθός, and ὀρθός, *straight*). A yellowish variety of Orthite from Eriksberg and Kullberg in Sweden.

Xanthosiderite (Gr. ξανθός, and σίδηρος, *iron*) A variety of Brown Iron-ore, occurring in yellowish-brown concentric and radiating aggregations of fine fibres with a silky lustre, at Ilmenau in the Harz.

Xanthoxylaceæ (Xanthoxylon, one of the genera). A natural order of hypogynous Exogens, closely allied to *Rutaceæ*, of which some botanists have regarded them as a section. They are distinguished from *Rutaceæ* chiefly by having unisexual flowers, with small spreading petals, a lobed ovary with two ovules in each cell, and lateral or basal styles often united at the top only, the fruit usually separating into distinct cocci varying from two to five in number.

The type of the order is *Xanthoxylon* (Gr. ξανθός, *yellow*, and ξύλον, *wood*), a rather extensive genus, having representatives in most of the tropical countries of the world, and in some parts of the temperate regions—one reaching as far north as Canada in the western, and several as far as Japan in the eastern hemisphere. The species differ considerably in appearance, some being large trees, while others are erect or climbing shrubs. The fruits of most of the species have an aromatic pungent taste like pepper. Those of *X. piperitum*, a Japanese species, are called Japan-pepper; and those of *X. hastile* are the Tej-bul of Northern India, where they are used for intoxicating fish. The popular name of Toothache-tree is applied to several American species (especially *X. fraxineum*), their bark and fruits being employed as a remedy for toothache. *X. caribæum*, a West Indian, and *X. nitidum*, a Chinese species, are reputed to be febrifugal; while the young prickly stems of *X. Clava-Herculis* are commonly made into walking-sticks in the West Indies.

Xebec. A small three-masted lateen-sailed vessel, constructed for conveying merchandise or stores: it is found chiefly in the Mediterranean and on the coasts of Spain and Portugal.

Xenelasia (Gr. ξενηλασία, *the expulsion of strangers*). An ordinance attributed to Lycurgus, which forbade strangers to reside in Sparta without permission, and empowered magistrates to expel strangers if they saw fit to do so. Pericles reproaches the Spartans for this, as being grounded on a fear of imparting dangerous knowledge to an enemy. (Thuc. ii. 39): it more probably arose from a desire to repress any liking for novelties or foreign fashions. (Xenophon, *De Rep. Laced.* xiv. 4.)

Xenolite (Gr. ξένος, and λίθος, *stone*). A fibrous kind of Sillimanite, found at Peterhoff, in Finland. It is a silicate of alumina, resembling Kyanite, of which it was formerly supposed to be a variety.

Xenotime (Gr. ξένος, and τιμή, *honour*). A phosphate of yttria, found at Ytterby in Sweden. The name has reference to the mistake which was made in supposing phosphate of yttria to be a new metal, to which the name Thorium was given, but which is now assigned to the metal discovered in the mineral called Thorite.

Xeque. The Spanish form of the Arabic Sheikh.

Xeringue. A South American name for the caoutchouc-yielding *Siphonia* and *Micrandra*.

Xerophagia (Gr. from ξηρός, *dry*, and φάγω, *I eat*). In Ecclesiastical Antiquities, a name given to the rigorous practice of certain fasts, during which nothing was consumed but bread with salt, and water. It was particular observed in Holy Week.

Ximenia (after Francis Ximenes, a Spanish writer on medicinal plants). The three or four species of this genus of *Olacaceæ* are either large shrubs or small trees, frequently armed with spines. *X. americana* produces oblong yellow fruits about an inch in length, which are eaten by the natives in various parts of the tropics, and which have an acid-sweet aromatic taste, with some degree of austerity. Its flowers are very fragrant, smelling something like cloves; and its wood is also odoriferous, and is used in India as a substitute for sandalwood, but it is obtainable only in pieces of small size. *X. elliptica*, a native of the Feejees and other islands of the Pacific Ocean, bears round orange-coloured fruits, of which the natives are very fond, though they are rather tart: before they are ripe they possess a powerful odour of essential oil of almonds. It also produces an extremely hard wood.

Xiphirhynchs (Gr. ξίφος, *a sword*, and ῥύγχος, *a snout*). The name given by Latreille to a family of Acanthopterygious fishes, of which the sword-fish (*Xiphias*) is the type.

Xiphosures (Gr. ξίφος, and οὐρά, *a tail*). A name of a tribe of Crustaceans, comprehending those in which the body terminates posteriorly in a long, hard, sword-shaped appendage.

Xylite (Gr. ξύλον, *wood*, and λίθος, *stone*). An asbestiform mineral from the Ural, allied to Xylotile in composition and structure, as well as in its brown colour.

Xylochlore (Gr. ξύλον, and χλωρός, *green*). A mineral closely resembling Apophyllite, and found in olive-green crystals in Iceland.

Xylography (Gr. ξυλογραφέω, *to write on wood*). Wood engraving. [Engraving.]

Xyloidin (Gr. ξύλον). A white granular substance, formed by the action of nitric acid upon starch, and upon certain modifications of

lignin: it is related to Schönbein's *gun cotton*. [PYROXYLINE.]

Xylol. A colourless liquid hydrocarbon, occurring among the oils contained in crude wood-spirit.

Xylophagans (Gr. ξυλοφάγος, *eating wood*). The name of a tribe of Coleopterous insects, comprehending those of which the larvæ devour the wood of trees in which they are developed; also applied to a family of Dipterous insects, the larvæ of which have similarly destructive habits.

Xylophilans (Gr. ξύλον, and φιλέω, *I love*). The name of a tribe of beetles, consisting of those which live on decayed wood.

Xylophylla (Gr. ξύλον, *wood*, and φύλλον, *a leaf*). A genus of *Euphorbiaceæ* or (as some regard it) a section of *Phyllanthus*, consisting of shrubs, without leaves, but having the branches flattened out and leaf-like, and bearing the flowers in tufts in the notches of their margin. The plants are natives of the West Indies and other tropical countries, and receive their generic name from the singular appearance of their leaf-like branches.

Xylopia. A genus of *Anonaceæ*, consisting of trees or shrubs indigenous to Brazil and other warm districts of South America, the West Indies, &c.

The species are noted for the bitterness of their wood, and the aromatic properties of their fruit and seeds. *X. frutescens*, a native of Cayenne, yields seeds which are eaten by the natives instead of spices. *X. grandiflora*, a Brazilian species, is sought for on account of its carminative fruits, which are also esteemed for their febrifugal properties. The Bitter-wood of the West Indies is the wood of *X. glabra*. Sugar placed in hogsheads made of this wood becomes so highly impregnated with the bitter flavour as to be useless, and even cockroaches will not touch the casks. The bark and fruits are said to taste like orange-seeds. *X. aromatica*, a native of South America, furnishes fruits used by the natives in place of pepper—hence the fruits are sometimes spoken of under the name of Ethiopian Pepper. *X. sericea*, a native of Brazil, also supplies aromatic pepper-like berries. The tough bark of this tree, as of *X. frutescens*, is in esteem, owing to the excellent cordage manufactured from its fibres. The fruits of *X. undulata* are employed in the Sandwich Islands in place of spice. Some of the Javanese spices, according to Blume, are not altogether free from noxious properties, for if too often or too largely partaken of, they give rise to vertigo and hæmorrhage.

Xyloretine (Gr. ξύλον, and ῥητίνη, *resin*). A crystalline resinous substance, found in certain varieties of turf.

Xylotile (Gr. ξύλον, and τίλος, *flock* or *down*). A delicately fibrous variety of Chrysotile, of various shades of wood-brown, and green, from Sterzing in the Tyrol.

Xylotroges (Gr. ξύλον, and τρώγω, *I gnaw*). The name of a tribe of Serricorn beetles, comprehending those which perforate timber.

Xyridaceæ (Xyris, one of the genera). A small natural order of Endogens, consisting of rush-like or sedge-like herbs, with fibrous roots, and long narrow radical leaves, the yellow flowers growing in heads which are enclosed in imbricate scales, at the top of leafless scapes. The perianth consists of three outer segments, of which one is more petal-like than the others, or of that one only, and either two or three inner petal-like segments. There are three stamens. The ovary is free, with three parietal placentas; and the capsule opens in three valves, containing numerous small albuminous seeds. The species are almost all tropical, dispersed over both the New and Old Worlds.

Xyst or **Xystos** (Gr. ξυστός, from ξύω, *I polish*). In Ancient Architecture, an open, or sometimes covered court, of great length in proportion to its width, with porticoes on three sides, used for the exercises of wrestling, running, &c.

Y

Y. A letter borrowed from the Greek υ. It is considered a consonant at the beginning, and a vowel in every other place, in English words. As a vowel, it has exactly the sound of *i*, being short or long according to its position. It is one of the letters represented by the Greek DIGAMMA.

Y Shaft of an Engine. The shaft for moving the valve, so called because in the old atmospheric engines the forked lever for giving motion to the valve or regulator was made in the form of the letter Y. The name is sometimes corrupted into *weigh shaft*.

Yacca. *Podocarpus coriacea*, which yields an ornamental wood used in the West Indies for cabinet-work under the name of Yacca-wood.

Yacht (Dutch jagt, Ger. jacht). A decked pleasure vessel. Yachts belonging to clubs recognised by the Admiralty have many of the privileges of the royal navy. This is an excellent arrangement, as they are an admirable nursery for daring seamen, and that without expense to the state. There are about 1,300 yachts in the several clubs of the United Kingdom, the average being about 30 tons.

Yagers or **Jägers** (Ger. *hunters*). Light infantry armed with rifles (*chasseurs, riflemen*). In the Prussian service, the yagers form a distinct corps with peculiar discipline; in that of Austria, light infantry generally from the mountain districts. In Germany the term *jäger* is applied to a peculiar species of higher servant attached to the families of the aristocracy.

Yam. The name applied to the fleshy edible roots of different species of *Dioscorea*, which are much cultivated as food in tropical countries. The common Yam is *Dioscorea sativa*. [DIOSCOREACEÆ.]

Yankee. The popular name for the New Englanders in America, and among English people indiscriminately applied to all inhabitants of the United States. Many ridiculous etymologies have been assigned for this word, which appears to be only a corruption of the word *English* by the Indians of North America.

Yanolite. A Mineralogical synonym of AXINITE.

Yapon. The South Sea Tea, *Ilex vomitoria*.

Yard (A.-Sax. geard, gyrd). The British standard measure of length. In early times the yard and ell appear to have been synonymous. The later ell, containing five quarters of a yard, was an introduction from the Low Countries. The imperial yard was defined to be 'the straight line or distance between the centres of two points in the gold studs in the straight brass rod now in the custody of the Clerk of the House of Commons.' This standard was destroyed in the fire which consumed the houses of parliament. With a view to recovering the measure, it was declared, that when compared with a pendulum vibrating seconds of mean time in the latitude of London, in a vacuum at the level of the sea, it would be in the ratio of 36 inches to 39 inches and $\frac{1393}{10000}$ of an inch. This calculation is, however, said to be inexact. The proportion of the yard to the mètre is as 3 to 3·280916.

The *yard* or virgate is also an ancient land measure, the exact quantity of which is not perhaps recoverable. It was probably determined by the quality more than by the quantity of land. It continued in use as late at least as the middle of the last century. [MEASURES.]

YARD. A spar suspended across a mast, by a rope called the *halliards* and *lifts*, for the purpose of extending a sail. A yard is called a *square yard* when hung horizontally by the middle: such a yard is adjusted to the wind by braces.

Yard-arm. In Naval language, the extremity of the yard. *Yard-arm and yard-arm* is a term descriptive of two ships engaging each other as close as possible.

Yarn. The threads of fibre of which the strands are composed which make a rope.

Yarrow (A.-Sax. gearwe, Span. yaro). The *Achillea millefolium* of botanists, a common native perennial weed of the Composite order, remarkable for its finely cut leaves, its large corymb, of small white flower-heads, and its strong aromatic odour. It yields a peculiar bitter principle. [ACHILLEINE.]

Yaruri. A Demerara name for the Paddle-wood, the strong but light and elastic timber of *Aspidosperma excelsum*.

Yaw. The Sea term for temporary deviation from a direct course.

Yawl. A decked boat carrying two masts, of which one is at the extreme stern. The rig is usually like a lugger.

Yaws. A disease in which eruptions form upon the skin somewhat resembling a raspberry. [FRAMBŒSIA.]

Year (A.-Sax. gear, Ger. jahr). A period of time determined by the revolution of the earth in its orbit, and embracing the four seasons. The year is either *astronomical* or *civil*.

The astronomical year is determined by astronomical observations, and is of different kinds, according to the celestial body or the point of the heavens to which the earth's revolution is referred. When the earth's motion in its orbit is referred to an immovable point in the heavens (to a fixed star, for example), the time of revolution is that which elapses from the instant at which the star, the sun, and the earth are in a certain relative position, till the earth returns again into the same position with regard to the sun and the star. This interval is called the *sidereal year*. But when the earth's motion is referred to a point of the ecliptic, as one of the equinoctial points or the tropics, the time of revolution is that in which the earth returns to that point, and is called the *equinoctial* or *tropical* or *solar year*. On account of the precession of the equinoxes [PRECESSION], the equinoctial and solstitial points, in reference to the fixed stars, have a retrograde motion on the ecliptic, in consequence of which the earth returns to one of these points in a shorter time than it returns to the same fixed star.

The length of the *sidereal year* is 365·2563612 mean solar days; or 365 d. 6 h. 9 m. 9·6 s.

The length of the *equinoctial* or *tropical year* is 365·2422414 mean solar days, or 365 d. 5 h. 48 m. 49·7 s. (Bailey's *Tables*, p. 16.)

The difference is 20 minutes 19·9 seconds of mean solar time, being the time in which the earth describes in its orbit an arc of 50·1″, the annual precession of the equinoxes. [EARTH.]

The earth's motion may also be reckoned by the time in which a revolution is completed with respect to the line of the *apsides* or the line of the *nodes*. In these cases the times of revolution may be called respectively the *anomalistic year* and the *nodical year*: the former term is sometimes met with.

The *civil year* is the year of the calendar. As it is always supposed to begin with the beginning of a day, the civil year contains a whole number of days; and hence, in order that the seasons may always correspond with the same parts of the year, it is necessary from time to time to vary the length of the year, or to intercalate a day when the fractional parts

neglected have accumulated to a whole day. The ancient Egyptian year consisted invariably of 365 days, and hence was called a *vague* or *erratic* year, because the first day of the year in the course of 1,460 years *wandered* as it were over all the seasons.

The *Julian year*, which is frequently employed in chronological reckoning, consists of 365¼ days. Julius Cæsar, advised by the astronomer Sosigenes, ordered that the civil year should consist of 365 days for three successive years, and that the fourth year should contain 366 days. This practice of intercalating a day every fourth year, has been adopted in all European countries, with the modification introduced by the Gregorian calendar. The mean Julian year is longer than the true tropical year by 11 m. 10·3 s., a difference which amounts to a whole day in about 120 years. The years which contain 365 days are called *common years*; those which contain 366 days are called *leap years*. [LEAP YEAR.]

According to the regulations of the Gregorian calendar, the intercalations are omitted in the years which end centuries, excepting when the number of the year is divisible by 4, after leaving out the two zeros. Thus the years 1700, 1800, 1900, which would be leap years in the Julian calendar, are common years in the Gregorian; but 1600 and 2000 are leap years in both calendars. [CALENDAR.] The mean length of the Gregorian year is 365 d. 5 h. 49 m. 12 s., exceeding the true tropical year by 22·38 s., which amounts to a whole day only in about 3,866 years.

The civil or legal year, in England, formerly commenced on March 25, the day of the Annunciation, though the historical year began on January 1, the day of the Circumcision. Between these two epochs it was usual to date the year both ways, as 1745–6, or $174\frac{5}{6}$. By the Act of Parliament for the alteration of the style in 1751, the beginning of the year was transferred to January 1. It is frequently necessary to keep this circumstance in mind in referring to old dates.

The fraction by which the tropical years exceed 365 days is ·2422414; and the series of approximating vulgar fractions alternately greater and less than this quantity is—

$$\frac{1}{4}, \frac{7}{29}, \frac{8}{33}, \frac{39}{161}, \frac{281}{1160}, \text{\&c.}$$

The fractions in this series indicate the intercalations by which the coincidence between the civil and solar year may be restored to any degree of exactness. The third, $\frac{8}{33}$, offers a very convenient mode of intercalation which would preserve the coincidence with great accuracy. It requires eight intercalations to be made in thirty-three years, i. e. one at the end of four years seven times in succession, and the eighth at the end of the fifth year. The mean length of the civil year would by this arrangement differ in excess from the solar year only by 15·38 seconds, while the Gregorian year is too long by 22·38 seconds. In a period of thirty-four years it therefore produces a nearer coincidence between the civil and solar years than the Gregorian method does in 400 years; and by reason of its shortness it also confines the evagations of the mean equinox from the astronomical within much narrower limits. The modern Persians are said, but not on very good authority, to intercalate in this manner. (Delambre, *Astronomie Moderne*, tom. 1.) [CALENDAR.]

Lunar Year.—Though the return of the seasons obviously depends on the motion of the sun, or rather of the earth in its orbit, some nations have chosen to regulate their civil year by the motions of the moon; and many others have formed luni-solar years, by combining periods determined by the revolutions of both bodies. The proper lunar year consists of twelve lunar months or lunations, and consequently contains only 354 days: its commencement, therefore, anticipates that of the solar year by upwards of eleven days, and passes through the whole circle of the seasons in about 34 lunar years. The inconvenience attending this circumstance has been so universally perceived, that, excepting the modern Jews and Mohammedans, almost all nations which have regulated their months by the moon have employed some method of intercalation for the purpose of retaining the beginning of the year at nearly the same place in the seasons. These methods are founded on certain luni-solar periods or cycles, which were established in the most ancient times, and which, with other relics of a barbarous age, are still preserved in our ecclesiastical calendars. [CALENDAR; CHRONOLOGY; CYCLE.]

Year to Year, Tenancy from. This is the common mode of letting houses or lands when occupied for more than a year without any definite term of years being granted. It is determinable at the option of either party on half a year's notice, but the notice must be given so as to expire at the end of a current year of the tenancy. Thus, as soon as the first half year of such a holding has expired, the tenancy becomes an absolute one for two years at least from the date of its commencement. When a house or land is occupied under an annual rent, and nothing is stated as to the duration of the occupancy, the law will assume that the tenancy was intended to be one from year to year.

Yeast (A.-Sax. gist, Ger. gäscht). The substance produced during the vinous fermentation of vegetable juices and decoctions, rising partly to the surface in the form of a frothy, flocculent, and somewhat viscid matter, insoluble in water and alcohol, and gradually putrefying in a warm atmosphere. It excites fermentation, and accelerates the process when added to saccharine and mucilaginous liquors. The nature of yeast, and the part which it plays in the process of vinous fermentation, have given rise to much theoretical discussion, and to many valuable investigations. (Pasteur, in *Annales de Chimie et de Physique*, third series, lviii. p. 323.) [BARM; FERMENTATION.]

Yeast Plant. It has been long known (observes Mr. Berkeley in the *Treasury of Botany*) 'that the particles of which yeast is composed germinate, and are multiplied with extraordinary rapidity when placed in a solution of sugar kept at a proper temperature. It was therefore at once allowed that the substance was organised, whether belonging to the animal or vegetable kingdom; and while some pronounced it an alga, others as confidently asserted that it was a fungus. Dr. Hassall and others observed that a particular mould grew pretty uniformly on a solution of malt; but we believe that Mr. Hoffmann, in union with Mr. Berkeley, first watched the growth of single yeast-globules in a drop of water surrounded by air enclosed in a glass cell, and ascertained that a *Penicillium* and a *Mucor* grew immediately from the globules. They were also convinced that these were not the only moulds to which the yeast-globules gave rise. It was clear, then, that yeast consists of a mixture of different moulds in a peculiar condition due to their developement in a fluid, and that when a fit opportunity offers, these globules are capable of being developed into their ordinary form. The globules, however, preserve their character without developing their perfect forms when the fluid in which they float is drained away, and in this condition the mass is called *German yeast*, a substance largely imported into this country, and both on account of its freedom from the bitter principle of hops, as well as from some peculiarities in its action on fermentable substances, often preferred to ordinary fluid yeast. It is a singular fact respecting yeast in this condition, that a sudden fall from a great height will sometimes completely destroy its power of vegetating.

'Yeast is of very different qualities, according to the nature of the liquor in which it is generated; and though there is little difference, if any, to the naked eye, the yeast-merchants distinguish several varieties, which, according to their respective energy and activity, are employed for different purposes. It has not yet been ascertained whether these different varieties are composed of the germs of different species of *Fungi*, or of the same species in different proportions. It is often said that yeast works by catalysis, but this is merely the substitution of a hard word for the naked fact that yeast promotes fermentation. There is no doubt, however, that it acts partly by presenting a large surface over which the fluid is spread, and thus favouring the disengagement of the carbonic acid gas, formed in the process of fermentation, exactly as that gas is set free when a lump of sugar or a piece of bread-crumb is placed in a glass of effervescent wine which has apparently previously parted with all the gas which it contained. It is moreover conjectured, that as chemical change always takes place when there is an interchange of two fluids of different densities separated by a membrane, the decomposition of a fermentable fluid containing yeast is favoured by this interchange, which is known to chemists and physiologists under the names of *endosmose* and *exosmose*.

'Substances which are hostile to the growth of fungi, generally, are hostile to fermentation. Hence a mixture of sulphites of soda, or the ignition of sulphur, are used to arrest the process where it is necessary.'

Yellow (A.-Sax. gealew, Ger. gelb, Lat. gilvus). In Painting, a colour of golden hue, and of many varieties. It is one of the seven so-called primary colours, and is complementary to blue, with which it forms white. [Colour; Light.]

Yellow Berries. The dried unripe berries of *Rhamnus infectorius*, imported in large quantities from the South of Europe and the Levant for the use of dyers.

Yellow Copper-ore. [Copper Pyrites.]

Yellow Earth or **Yellow Iron-ochre.** A mixture of Limonite (hydrated peroxide of iron) with hydrated silicate of alumina, found at Pary's mine in Anglesea, in the Forest of Dean in Gloucestershire, France, Bavaria, the Harz, and elsewhere. It is sometimes used as a coarse yellow pigment, and is stated by Bunsen to be a valuable antidote to the poison of arsenic. [Yellow Ochre.]

Yellow Fever. This disease is described under two forms, one being a bilious fever, of malarious origin, in which the remissions are so connected that the disease rather resembles a continued fever. The skin becomes yellow during its progress. Intense heat assists much in producing this fever wherever marshy lands exist.

The other form, or the specific yellow fever, is of continuous type, and is considered contagious. It is attended by yellowness of skin, delirium, suppression of urine, black vomit, black dejections, and small, thready, intermitting pulse. This disease becomes endemic in low sea-coast districts, rarely occurring at an elevation more than 2,500 feet above the sea level. It has been stated, however, that it once prevailed in Jamaica at a height of 4,000 feet above the sea. Some writers regard the two forms of fever here described as being essentially the same, and only varying in the degree of malignancy.

Yellow Lead-ore. [Wulfenite.]

Yellow Mineral Resin. [Amber.]

Yellow Ochre. An earthy variety of Brown Iron-ore, which occurs in amorphous and earthy masses, of a dull yellow colour and streak, in the Forest of Dean in Gloucestershire, France, Bavaria, &c. It leaves a yellow trace when drawn across paper, and is used as a pigment. [Yellow Earth.]

Yellow Orpiment. Yellow arsenic or sulphuretted oxide of zinc, of a beautiful bright and pure yellow colour, used as a pigment. In its native state it is used under the name of *Zarnic* or *Zarnich*, varying in colour from warm yellow to greenish yellow. Orpiment in all its varieties, as a colour, is subject to change and to be changed by all pigments containing oxygen; and if used must be employed alone.

Much of the artificial Orpiment is only a glassy variety of arsenious acid, coloured with a variable proportion of yellow sulphide of arsenic, and is of no definite composition. It is produced by subliming arsenious acid and sulphur.

Yellow Tellurium. [SYLVANITE.]

Yenite. A name given to LIÉVRITE in commemoration of the battle of Jena.

Yeoman (A.-Sax. gemæne, Ger. gemein, *common*). Camden ranks yeomen as the next class to the gentlemen, and calls them *ingenui*. The name seems to have been generally appropriated in the middle ages to small freeholders below the rank of esquire. In several departments of the royal household, there are subordinate officials, styled *yeomen*.

YEOMAN. A seaman appointed to certain duties, as to attend to the storerooms.

Yeomanry Cavalry. A denomination given to those troops of horse which were embodied during the revolutionary wars of France, and afterwards among the gentlemen and yeomen of this country. There are at present (1867) 48 corps, comprising 264 troops, and forming a total of 14,268 of all ranks. Arms and ammunition are provided by the War Office, and there is an allowance of 2*l*. per man per annum; each man has to provide his own horse. The yeomanry are volunteers, but are liable to be called out in aid of the civil power in case of riot at any time; and in case of actual invasion or appearance of an enemy on the coast, or during a rebellion, they may be assembled for actual service; they are then subject to the Mutiny Act and Articles of War, and may be called on to serve in any part of Great Britain. [VOLUNTEERS.]

Yeomen of the Guard. [GUARD, YEOMEN OF THE.]

Yew. [TAXUS.]

Yezdigird, Era of. [ÆRA.]

Yezidis. [JEZIDS.]

Ynca. [INCA.]

Yoke (Ger. joch, Fr. joug, Lat. jugum, Gr. ζυγόν, *that which joins two things together*). A piece of wood or light frame of two arms, placed over the head of a boat's rudder instead of a tiller, and having two lines (*yoke lines*), by pulling on which the boat is steered. It is the most convenient arrangement in a narrow boat.

Yoni. The Hindu name for the female power in nature. The Yoni is the special emblem of Vishnu. It is exhibited in the form of a vesica, and is the boat-shaped vessel of which Iswarra is the lord, reproduced in the symbol spoken of by Tacitus as 'signum in modum liburnæ figuratum,' as well as in the ship over which the PEPLUS was carried in the Panathenaic procession. Ornaments in the shape of a complete or imperfect vesica have been popular in all countries as preservatives against dangers, especially from evil spirits; hence the practice of nailing up horseshoes on walls by way of protection against unknown perils, and of throwing a shoe after a newly-married pair by way of securing good luck. The name Yoni belongs to the root *jan*: for cognate words from the same source, see LANGUAGE. [LINGA; MYSTERIES; PHALLUS; SACTI.]

Ypoleime (Gr. ὑπόλειμμα, *a remnant*). [PHOSPHOROCHALCITE.]

Ytterbite. A Mineralogical synonym of Gadolinite, after one of its localities, Ytterby in Sweden.

Yttria Spar. [XENOTIME.]

Yttrium. The metallic base of an earth, discovered in 1794 by Gadolin in a mineral found at Ytterby in Sweden, whence it was called Yttria. The metal was first obtained by Wöhler in 1828: it is of a dark grey colour, and brittle. Very little is known of yttria or its salts. According to Mosander, three bases have been confounded under the name of yttria, two of which he distinguishes as ERBIA and TERBIA.

Yttro-Columbite. [YTTRO-TANTALITE.]

Yttro-Ilmenite. [SAMARSKITE.]

Yttrocerite. A native sesquifluoride of cerium, with fluoride of yttrium and fluoride of calcium (Fluor-spar), from Finbo and Broddbo in Sweden.

Yttrotantalite. A mineral from Ytterby, in Sweden, and the Ilmen Mountains in the Ural; composed chiefly of Yttria and Tantalum.

Yu. The Chinese name for Jade or NEPHRITE.

Yucca (Yuca, its name in St. Domingo). A genus of *Liliaceæ*, sometimes assuming an arborescent habit, producing a crown of linear-lanceolate more or less rigid leaves, and from the centre of each crown a tall erect panicle of showy whitish flowers. They are chiefly found in the Southern States of America and in Mexico, one or two extending to tropical America. They are very handsome garden plants, most of them nearly or quite hardy. In *Y. gloriosa*, one of the stateliest of the species, the crown of leaves becomes elevated on a stout stem, and the panicle is three feet or more in length, branching out on every side. In some, as *Y. filamentosa*, the leaves give off from their margin thread-like bodies, which hang loosely; and in one tender species, *A. schidigera*, these bodies are so large and broad as to resemble carpenters' shavings. The leaves, treated like hemp and flax, afford a fibre which may be used in the manufacture of cloth or cordage; and the macerated stems deposit a feculent matter, from which starch may be obtained. At Carthagena a starch or glue of this kind is made from the stem of *Y. gloriosa*.

Yugs or **Yogues.** Hindu eras or periods, four in number, and extending over millions of years. [SOTHIAC PERIOD; TABULATION OF CHRONOLOGY.]

Yule. The common Scottish name for Christmas. It appears to be a very ancient Celtic word. In Welsh, wyl or gywl signifies a holiday; whence also the old phrase *Gule of August*, the first day of August, or fast of St. Peter ad Vincula, for which various absurd

etymologies have been found. Possibly the old French word *Noël* for Christmas (used also generally as a popular cry of rejoicing) has the same original. (*Archæol.* vol. ii.) Some, however, derive yule from a supposed primitive word, connected with the idea of revolution or *wheel*; while Mallet (*Northern Antiquities* ii. 68) traces it to hiaul and houl (Lat. sol, Gr. ἥλιος), the word for *sun* in the dialects of Brittany and Cornwall. The term on the last supposition refers to the winter solstice. (Brand's *Popular Antiq.* vol. i. p. 346.)

Z

Z. The last letter in the alphabets of all the modern languages, usually regarded as a double consonant, from its having the sound in some languages of *ts* or *ds*. Like the letter *x*, it begins no word originally English; and Dr. Johnson has remarked, that although it is found in the Saxon alphabets, set down by grammarians, it is read in no word originally Teutonic.

Zachun. A fixed oil, expressed from the seeds of *Balanites ægyptiaca*.

Zaffre. This word is applied to the residues obtained by roasting native arsenides of nickel and cobalt, mixed with a certain proportion of silicious sand. The roasted ore without such addition is known as SAFFLOR. The process of roasting is conducted in such a manner as to leave a sufficient quantity of free arsenic in the product to yield a fusible arsenide or *speiss* of nickel in the subsequent fusion in the smalt furnace. By the addition of carbonate of potash, and fusion, Zaffre is converted into a blue glass, which, when ground and levigated, produces the colour known as *smalt blue*.

Zafran. The Indian name for *Crocus sativus*, whence our name Saffron.

Zagreos (Gr.). In the Orphic *Theogony*, the horned child of ZEUS and PERSEPHONE. He is the favourite of his father, and is represented as seated on the throne beside him, guarded by Apollo and the CURETES. But as in the case of Io, Hera is jealous, and incites the Titans, who kill the child with a sword while he is amusing himself by looking at his own face in a mirror. They then cut up his body and boil it in a cauldron; but Athena bears his heart to Zeus, who punishes the Titans by hurling them into Tartarus. The heart is given to Semele, and Zagreos is born again from her under the form of DIONYSUS. For the probable age of the Orphic *Theogony*, see Grote, *History of Greece*, part i. ch. i.

Zakkoum. An oil obtained in Palestine from *Elæagnus hortensis angustifolia*.

Zaleucus (Gr. Ζάλευκος). The mythical or semi-mythical legislator of the Epizephyrian Locrians. He is described by Diodorus as a disciple of Pythagoras; but nothing can be satisfactorily ascertained from the contradictory legends respecting his life, and in fact his code of laws seems to be the only evidence of his personal existence. How far such evidence can settle the question, can be determined only by a diligent scrutiny of the tales which have gathered round the names of Lycurgus, Numa, ROMULUS and SERVIUS TULLIUS.

Zalmoxis or **Zamolxis** (Gr.). In the Thracian Mythology, a god who dwelt beneath the earth, like Andvari in the Volsung tale. [SIGURDR.] The rationalised Greek version of the myth states that Zalmoxis was a slave of Pythagoras at Samos, and that by abilities and artifice he gained a religious ascendency over the minds of the Thracians. This story Herodotus (iv. 94) refuses to believe. (Grote, *History of Greece*, part i. ch. xvi.)

Zambarone. A Sicilian name for the fibre of the *Agave*, used for making cordage and mats.

Zamia. A genus of *Cycadeaceæ*, consisting of moderate-sized trees, having much of the appearance of palms, and in some particulars of ferns. They have stout generally unbranched stems terminated by tufts of thick pinnated leaves, often spiny at the margins or points. The male and female flowers are borne in cones, composed of woody scales, with a truncated six-sided summit, and each scale of the female flower has two seeds.

The species are natives of Central America, the West Indies, the Cape of Good Hope, and South-eastern Africa, where they frequently constitute a conspicuous feature in the vegetation. The stems of these plants contain an abundance of starchy matter, which is sometimes collected and used as arrowroot. *Z. tenuis* and *Z. furfuracea* are employed for this purpose in the Bahamas. There is abundant evidence to suggest that in former ages some of these cycads grew in this country, as fossilised stems of plants apparently belonging to this or to a closely allied genus are found in abundance in some of the oolitic strata in the Isle of Portland, where they are known to the workmen as fossil birds'-nests, or fossil pineapples.

Zamite. Fossil zamia.

Zasmidium. A genus of Fungi, including that known as the Cellar Fungus. This species, *Z. cellare*, observes Mr. Berkeley, 'is commonly known as hanging down from the roofs of cellars in large masses, or covering corks, bottles, and other matters. It sometimes even penetrates the tissue of the corks, but does not seem to injure the wine like some of the white mycelia. Indeed, the wine merchant en-

courages its growth, as he thinks it an ornament to his vaults, and an indication to customers who visit them that his wine is old.' The cellar fungi are, however, sometimes very injurious.

Zavalite. The name given to a hydro-carbonate of nickel found in Spain; it is probably identical with Emerald-nickel.

Zea (Gr. ζεά, Sansc. and Zend yova, Lith. jawas). A genus of grasses of which *Z. Mays*, or Maize, is the well-known and important cereal so largely grown in the United States of America, where it is generally known under the name of Indian-corn. Though not now found in a wild state, there is little doubt that America is the native region of this plant. Maize is largely cultivated throughout most of the warm-temperate zones of the globe, and probably ranks next to rice as the grain which affords nutriment to the largest number of human beings. It has many qualities to recommend it for culture where the climate is sufficiently warm to ripen the grain properly, growing as it does freely in very different kinds of soil, as well as under dissimilar states of moisture and dryness. The crop is easily saved, and with ordinary care the grain is as easily preserved. Some of the finest samples which have reached Britain in the cob or ear have been grown in Australia, where the climate is very favourable for producing Indian-corn. It is also extensively consumed in many parts of Africa. More than 7,000,000 cwt. of Indian-corn were imported into this country in 1865, the computed value of which was 2,234,396*l.*

Zeagonite. A Vesuvian mineral found in rhombic crystals on Somma. It is identical with GISMONDINE.

Zebra. A name applied, in a general way, to striped species of the section *Asinus*, of the horse kind (*Equidæ*), characterised by a longer tail, tufted at the end, by callosities on the inner side of the fore legs only, and by *braying* instead of *neighing*. Of these striped wild asses, three species are defined: the Zebra proper (*Equus Zebra*, Linn.), the Quagga (*Equus Quaccha*, Gmel.), and Burchell's Zebra (*Equus montanus*, Burch.).

Zebra Wood. A beautiful fancy wood used by cabinet makers, and obtained in Demerara from a tree called *Omphalobium Lamberti*. Another kind is obtained from the wood of the West Indian *Eugenia fragrans*.

Zechstein (Ger.). The upper or calcareous member of the Permian system is thus named in Germany. It consists of: (1) a marly series, *Letten*, often containing rolled fragments of dolomite and crystals of gypsum. It is generally a greyish, bluish, or greenish clay. (2) A fetid limestone, *Stinkstein*, a compact or granulated rock of blackish brown or green colour. (3) A hard cellular magnesian limestone, *Rauwacke*. The whole thickness reaches nearly 100 feet. The zechstein occasionally contains copper ores of galena.

Zedoary. The name by which certain species of *Curcuma* are known. Thus *C. Zerumbet* is the Long Zedoary, and *C. Zedoaria* the Round Zedoary of the shops. They are aromatic plants related to gingers.

Zeilanite or **Zeylanite.** A species of Pleonaste (Spinel) found in black octahedrons, near Candy in Ceylon, from which circumstance it has also been called *Candite*.

Zemindar (from the Persian zemin, *land*). A title introduced into India by its Mohammedan conquerors, conferred in Bengal, and generally throughout the Mogul empire, on the agent employed to collect that share of the produce of the soil which belongs to it. The zemindars were the great landowners of the Mogul empire; but the nature of their tenure has given rise to much dispute. Whether they were hereditary absolute owners of the soil, or only tenants of the sovereign at a fixed rent by way of land-tax for which they were personally responsible, was a question much agitated by writers on Indian subjects at the period of the 'Permanent Settlement' in 1793. By that settlement the rent was to be fixed in the first instance by custom, and the zemindar was then to give the ryot a lease restricted to himself and his assignees on performance of its conditions; his own share being fixed as before at 10 per cent. of the assessment, and his hereditary right secured. A zemindary, i. e. the district of a zemindar, is liable to be sold by government for arrears of revenue, and existing leases with the ryots to be set aside. The zemindary system was a failure. The men who were appointed to this position were frequently persons of low caste, and were despised by the natives. They abused their privileges, to oppress the peasantry, and squandered their resources in extravagance and profligacy. (See Dr. Whewell's edition of the works of Professor Jones; Mill's *History of British India*, vol. v.; M'Culloch's edit. Smith's *Wealth of Nations*, note 19; *Ed. Rev.* vols. xxxi. lxxi.) [RYOT.]

Zenana. This Persian word, more properly written *Zanana*, is used to denote the apartments in Eastern houses set apart for the use of the women in a family.

Zend. The language in which the books of the ZEND AVESTA are composed.

Zend Avesta. The sacred books which embody the religious system of ZOROASTER. The text of these books was brought to Europe by Anquetil du Perron, in the form of a modern Persian translation of the original; but the first European scholar who acquired a knowledge of the Zend language was Eugène Burnouf. This language is closely allied to the Sanscrit of the Veda, and it was chiefly by aid of the latter that the Zend MSS., preserved by the Parsee priests of Bombay [PARSEES], were deciphered. The word Zend is connected by Professor Max Müller with the Sanscrit *chhandas*, a name given to the Vedic hymns [VEDA], Avesta meaning *a settled text*, from the Sanscrit Avasthita, *settled* or *laid down*. The Zend Avesta now consists of four books, the fourth and most celebrated being the Vendidad, which contains an account of the temptation of

Zoroaster, and also furnishes evidence for the existence of *Airya* (Aryans) as a national appellation, the whole space of Asia, vîspem airyô-s'ayanem, being contrasted with the non-Aryan countries, anairyâo dain-hâvô. (Max Müller, *Lect. on Language*, first series, v.—vii.; Gibbon, *Roman Empire*, ch. vii.; Milman, *Hist. of Christianity*, bk. i. ch. ii. and bk. iii. ch. i.)

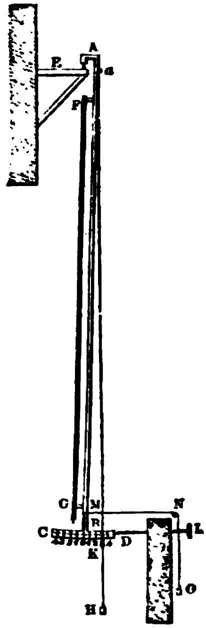
Zendik. In Arabic, a name given to those who are charged with atheism, or, rather, disbelief of any revealed religion, or with magical heresies. The sect of Zendiks opposed the progress of Mohammedanism in Arabia with great obstinacy. It appears to have had many features in common with Sadduceeism among the Jews.

Zenith (from the Arabic). In Astronomy, the top of the heaven, or vertical point; the point directly overhead. The zenith is that point of the celestial sphere which would be intersected by the plumb line, supposed to be indefinitely extended. It may also be defined as the pole of the horizon, from which it is 90° distant. All vertical circles or azimuths necessarily pass through the zenith.

Zenith Distance. The angular distance of any celestial object from the zenith; or the complement of the altitude of the object above the horizon.

Zenith Sector. An astronomical instrument, contrived for the purpose of measuring with great accuracy the zenith distances of stars which pass near the zenith. It was by means of a zenith sector that Bradley discovered the existence and magnitude of two most important astronomical elements—the aberration of light and the nutation of the earth's axis. The instrument has also been generally used (in this country at least) in trigonometrical surveys for determining the difference of latitude of two stations, a purpose for which it is very convenient; for the difference of the zenith distances of the same star, observed at its meridional passages at two places, gives the difference of the astronomical latitudes of the places without any regard to the star's declination. The general description of the zenith sector has been given by the present Astronomer Royal as follows (*Ency. Metr.* art. 'Figure of the Earth'):—

'In the annexed figure AB is a bar of iron with a cross piece CD, the whole in one piece. The top A is formed in such a way that the instrument can be turned half round in azimuth when suspended at the top, and that the bottom can be moved freely in the directions DC or CD. The bracket or other support E, on which it rests, is attached to some firm part of the building. To the bar AB is firmly attached a telescope FG. At a point *a*, near A, is attached a plumb line *a*H; sometimes it is fastened at a point of attachment which is movable, in order that by moving the point of suspension the plumb line may be made to pass over a fine dot at *a*. The limb CD is graduated, sometimes on a circular arc of which *a* is the centre, and sometimes on a straight line. LD is a screw passing through a block strongly connected with the floor, and acting with its point against the end D of the piece CD; and MNO are a string and weight pressing the sector against the point of the screw.'



The method of observing with the zenith sector is this: A clock being regulated by transits of stars, the direction of the meridian is found, and guides fixed to compel the sector to move in the meridian. When a star is to be observed, the screw LD is turned till the plumb line falls exactly on some point K of the graduated arc, such that the telescope is very nearly directed to the point through which the star will pass when it comes to the meridian. When the star enters the field of view, the screw is again turned till it appears to glide exactly along the horizontal wire fixed in the focus of the eye-glass; and the motion of the screw being ascertained, and the value of the divisions known, the apparent zenith distance of the star is found. But it is evident that this is not the true zenith distance, unless the zero point of the divisions on the scale be quite accurate, i. e. so placed that when the plumb line falls on it the optical axis of the telescope shall be exactly vertical. It is impossible to insure this accuracy; but it is easy to see that if the instrument be turned half round in azimuth, and the same observation made, the apparent zenith distance will be just as much greater than the true as in the former determination it was less. The mean of the two will therefore be the true zenith distance of the star.

The advantages of the zenith sector are these: The stars observed being very near the zenith, the tremor and dancing which generally affect stars in other positions are seldom seen; there is no uncertainty about the effects of refraction; the telescope and the whole instrument are not subject to flexure; and the variation of temperature produces no sensible effect.

For a detailed account of Ramsden's zenith sector used in the measurement of the English arcs of the meridian, see the second volume of the *Trigonometrical Survey of England and Wales*, or *Phil. Trans.* for 1803. This superb instrument was unfortunately burnt in the great fire which took place in the tower of London

in October 1841. Another sector, on a different plan from that above described (the zenith point being determined by levels), has been constructed for the use of the survey by Troughton and Simms, under the direction of the Astronomer Royal. A description and drawing of the new instrument is given in the *Monthly Notices of the Royal Astronomical Society* for May 1842.

Zeolite (Gr. ζέω, *to boil*). A name formerly given to Mesotype and Stilbite. It is now, however, used in a more extended sense to denote a family of silicates, the chief distinguishing feature of which is that they always contain a large proportion of water, varying from 4 to 20 per cent. They also possess in common the property of melting with considerable ebullition before the blowpipe, and of forming a precipitate of gelatinous silica in hydrochloric acid, and of yielding a colourless streak.

The Zeolites usually occur in volcanic rocks in the form of crystals, or of foliated and radiated masses, filling cavities, veins, and fissures—sometimes, as in basalt, they constitute an essential ingredient of the rock itself. The principal species composing the group of Zeolitic minerals are: ANALCIME, APOPHYLLITE, CHABAZITE, GMELINITE: HARMOTOME, HEULANDITE, LAUMONTITE, MESOLITE, NATROLITE, PHILLIPSITE, PREHNITE, SCOLEZITE, STILBITE, THOMSONITE.

Zephyrus (Gr. ζέφυρος, akin to ζόφος, *darkness*, a word which has many forms, as δνόφος, γνόφος, κνέφας, νεφός, νεφέλη, Lat. nubes). In Greek Mythology, the west wind blowing from the dark land, in which dwell NEPHELÊ and the children of the mist. In the Hesiodic *Theogony*, Zephyrus is described as a son of Astræus (*the starry*) and Eos (*the morning*). By the Harpy Podargê (of the glistering feet) he became the father of Xanthos and Balios, the undying horses of Achilleus. [CHARITES.]

Zero (Ital.?). A term generally used in reference to the thermometer, implying the point at which the graduation commences. The zero of Réaumur's and of the centigrade thermometer is the freezing point of water. The zero of Fahrenheit's scale is 32° below the point at which water congeals, being about the temperature of a mixture of salt and snow. [THERMOMETER.]

Zetes (Gr. ζήτης). In Greek Mythology, a son of Boreas and Oreithyia. Like his brother Calais, he was born with wings, and took part in the Argonautic expedition. [MYSTERIES.] They were engaged also in pursuit of the HARPIES, and were slain by HERACLES in Tenos.

Zeugite (Gr. ζευγίτης, *yoked* or *joined together*). A native phosphate of lime which is met with in white or slightly yellowish and brownish amorphous masses, in guano at the Key of Sombrero.

Zeuglodon (Gr. ζεύγλη, *a yoke*, and ὀδούς, *a tooth*). A genus of gigantic cetacean animals, the remains of which have been found in the miocene strata of Europe and North America. The teeth of this carnivorous whale were first described and figured by the mediæval palæontologist Scilla. The American remains have been erroneously referred to a genus of reptiles, and termed Squalodon, Basilosaurus, and Dorudon by various American authors. The entire skeleton of the largest species (*Zeuglodon Harlani*) indicates an animal about seventy feet in length. The skull is very long and narrow; the nostril single, with an upward aspect, above and near the orbits. The jaws are armed with teeth of two kinds, set wide apart; the crown of the tooth being contracted from side to side in the middle of its base, so as to give its transverse section an hour-glass form (whence the name). The Zeuglodonts form a distinct family of Cetacea, intermediate between that order and the Sirenia.

Zeugma (Gr. *a yoke*). A figure in Grammar, by which an adjective or verb which agrees with a nearer word is referred also, by way of supplement, to one more remote.

Zeus (Gr.). This name for the supreme god of the Greeks is etymologically identical with the Sanscrit *Dyaus*, the Latin *Jovis* (Jupiter), the Anglo-Saxon *Tiw* [TUESDAY], the Eddic god TYR, the Old High German Zio. The analysis of language and mythology shows that this god was originally the supreme deity of the whole Aryan family of nations. Among the Hindus this deity was at a comparatively early period eclipsed by Indra, the god who by smiting VRITRA brings rain upon the earth; but Indra is himself the son of Dyaus-pitâr, the Ζεὺς πατὴρ of the Greeks, the Diespiter and Jupiter of the Latins. This name Dyaus is derived from the same root which yields the verb *dyut*, to beam; and in the modern Hindustani dyu remains the name for *sky* and *day*, with which latter word it is identical. In this fact we have the reason for the slender hold which the name retained in the formation of their mythology. Among the Homeric Greeks, with whom words like ἀήρ, αἰθήρ, and οὐρανός, were the common names for air, æther, and heaven, Zeus became more and more a person, being either exalted as the Supreme Impassible Creator, just and holy, or debased by the anthropomorphising process inseparable from the growth of mythology. But although the name ceased to be to the Greek a mere appellative for the heavens, still, in harmony with the original idea, Zeus in the partition of all things remains the lord of the æther or highest heaven, while he bestows the nether regions on HADES, and the sea on POSEIDON. The same idea is manifest in the prayer, ὗσον, ὦ φίλε Ζεῦ, κατὰ τῆς ἀρούρας τῶν Ἀθηναίων (*rain, O dear Zeus, on the land of the Athenians*), as well as in the expression of Ennius, Aspice hoc sublime candens quem invocant omnes Jovem (*see this glistening heaven which by all is named Jove*). With these may be compared the phrases, *sub dio vivere*, to be in the open air; *sub Jove frigido*, under a cold sky; *malus Jupiter*, stormy weather. Of the original epithets of Dyaus, some were transferred to Indra, who thus becomes, for

example, Indra-sthâtas, the Jupiter Stator of the Latins.

Thus, then, among the Greeks, the conceptions of Zeus parted off into two streams almost at the fountain head. On the one hand we have the anthropomorphised god, with his relations to other gods and beings duly defined according to the laws which determine the growth of myths; on the other, we find the idea (which, as time goes on, becomes clearer and stronger) of an Infinite and Eternal God, holy, just, and true, who desires righteousness in men and watches over them for their good. Although the mythical notions come uppermost in the language of ordinary life, yet, whenever the man is thrown back upon his own thoughts in times of need, distress, or excitement of any kind, he reverts instantly to a Zeus, who has nothing in common with the Zeus of the Homeric Olympus. For this Zeus is capricious, tyrannical, and lustful, as every being must be for whom language, both harmless and beautiful when applied to the phenomena of the heavens, has been translated into the conditions of human society; and such a Zeus could be no fit object of reverence, for, in the words of Euripides,

εἰ θεοί τι δρῶσιν αἰσχρὸν, οὐκ εἰσὶν θεοί.

'If the gods do aught unseemly, then they are not gods at all.'

Zeus then, as the sky or air, might be regarded as producing time or as produced by time. In the former case he would be Zeus Kronion, or the ancient of days: in the latter, he would be the son of Kronos, who is probably nothing more than a mythical being evoked from that which had been a mere epithet. But the air or heaven covers everything as with a garment, and so Zeus would be Ouranion; from which name sprang the concrete Ouranos [Uranus], who in the Hesiodic *Theogony* is assigned as a father to Kronos, and who reappears in the Vedic Varuna. Having advanced thus far, the growth of the myth next assigned to him a wife in Hera, a name connected by some with the Sanscrit svar, *the bright sky*, and sûrya, *the sun*. (Cox, *Manual of Mythology*, p. 24.) But the bright heaven through which the sun journeys may be regarded as the cause of all fertility, and the fruits of all lands may be looked upon as his children; and thus Zeus, like Heracles, became a being who had his earthly loves wherever he went, and took pride in recounting their numbers. It is obvious that the extension of this process must render the character of the being portrayed continually more gross and repulsive; and thus we have in Pindar and in Plato strong expressions of disgust for the coarseness and immorality of tales which were not only harmless but exquisitely graceful in their original form. [Theology.]

But while the mythical descriptions were becoming more and more sensual, the conception of the spiritual Zeus was becoming more pure and refined. The former process is seen in the Hesiodic *Theogony* as compared with the Homeric poems, the latter in the Hesiodic *Works and Days*. This poem, which in the view taken of human life exhibits a temper not unlike that of the book Ecclesiastes, manifests a religious spirit which cannot be too carefully taken into account. Zeus here is the avenger of injustice (237); he looks down from heaven upon the children of men to see if they will do righteousness (247); the eye of Zeus is everywhere, and he knows all things (265); and for the good of men he has ordained labour to be the lot of their life (287). But even in the Homeric poems, the Zeus to whom real prayer is offered is not the Zeus who indulges himself in sensuality and cruelty; the prayer of Achilleus is not offered to a lying god who owns no law for himself and cannot be a law for man. The later poets rise to the knowledge that the word Zeus is a mere name, utterly inadequate to express the conception of the Infinite and All-righteous Maker and Preserver of all things.

The etymological changes of the name are almost numberless. To those which have been already mentioned may be added the forms connected with it by the transition of *dy* (Dyaus) into *j* (Jupiter) or *dj*, as in the old form Diovis, met with in Oscan inscriptions, in the old Italian divinity Vejovis, in Jan, the older form of Janus (January), which again is the same as Juno, and is resolved also into Dianus and Diana. This last name with the so-called Digamma becomes Divâna, the heavenly, dív-inus, the divine. Akin to the root of Dyaus, is the Sanscrit deva, *a god*, a word denoting originally *brightness*; and thus Vritra is called adêva, the *atheist* or enemy of the gods. Deva then is the Latin Deus, the Greek θεός, the Lithuanian Diewas.

The common Homeric epithet of Zeus, εὐρύοπα, or *broad-faced*, explains itself, and is referred to the class which includes Europa, Euryanassa, &c. [Telephassa.]

The cave of Dictê, in which, according to the Cretan legend, Zeus was born, is the cave or abyss from which springs the light of day. The name Dictê belongs, as some have thought, to the same root with δείκνυμι, *to show*; Sanscrit, dic; Latin, indicare; German, licht, zeichen; English, *light*, *token*. To this root also belongs, probably, the epithet Dictynna, applied to Artemis as employing δίκτυα, or nets, in hunting, and the name of Dictys, who rescues Danaê from the sea at Seriphos.

For a more full examination of the subject, the reader is referred to Max Müller, *Comparative Mythology*, and *Lectures on Language*, second series, x.; Bréal, *Hercule et Cacus*; Cox, *Gods and Heroes*, and *Thebes and Argos*, Introductions. The mythical relations of Zeus to gods and men are minutely traced by Mr. Grote (*History of Greece*, part i. ch. i.); and the most important of these are noticed in the following articles: Aphroditê; Arês; Charites; Hephæstus; Hera; Heracles; Hermes; Io; Lycaon; Memnon; Minerva;

PANDORA; PARIS; PERSEPHONE; PERSEUS; POSEIDON; PROMETHEUS; RHEA; SARPEDON; SEMELÊ; TANTALUS; THESEUS; TITANS; URANUS; VESTA; ZAGREOS.

Zeuxite (Gr. ζεῦξις, *a yoking*, from its occurrence in the *United Mines*). A variety of Iron-Tourmaline formerly met with at Huel Unity in Cornwall, in small translucent and acicular blackish-green crystals much interlaced, and having the appearance of asbestiform Actinolite. It is a ferro-silicate of alumina.

Zeysoum. An Egyptian name for the flower-heads of *Santolina fragrantissima*, a substitute for chamomiles.

Ziega or **Serai.** After rennet has ceased to produce the coagulation of milk, the addition of acetic acid occasions a further separation of curd, to which the above names are applied.

Zieria (after M. Zier). A genus of *Rutaceæ* confined to the continent of Australia, and chiefly to the eastern coast, extending as far as the tropics. They are small trees or shrubs, with opposite simple or trifoliate leaves, full of pellucid dots; and they usually bear axillary, few or many flowered panicles of white flowers.

The *Z. lanceolata* of Tasmania is a shrub, and is called Stinkwood by the colonists, on account of its fetid smell. One common at Illawarra, and there called Turmeric-tree, has a very yellow inner bark, suitable for dyeing, and also a yellow close-grained hard wood, which is valuable for ornamental purposes, and probably might be used for engraving.

Zigzags. In the attack of a fortress, approaches connecting the parallels. They are directed so that their prolongations fall alternately to the right and left of the fortress, and clear of the most prominent salients of the covered way. [FORTIFICATION.]

Zillah (Hind. Zilâ). In British India, the designation of a province or tract of country constituting the district of a commissioner or circuit judge, and the extent of a chief collectorate.

Zinc (Ger. zink, perhaps akin to zinn, *tin*). (Zn.) This metal was first mentioned by Paracelsus, but its ores were resorted to at a much earlier period for the manufacture of brass. The zinc of commerce is procured from the native sulphide (*blende*) or from the carbonate (*calamine*). The ore is wasted in a reverberatory furnace (by which carbonic acid is driven off from the calamine, and sulphur from the sulphide), and is then mixed with charcoal, and put into earthen pots, not unlike oil-jars, six of which are usually placed in a circular furnace. Each pot has an iron tube passing from its lower part, through the floor of the furnace, and dipping into water; they are everywhere else firmly luted. Upon the application of a full red heat, the metal distils through the tube into the water beneath, whence it is collected, melted, and cast into cakes. This process is called *distillatio per descensum*. Commercial zinc generally contains traces of sulphur, iron, and arsenic.

Zinc is a bluish-white metal, rather hard, of a specific gravity of 6·8 to 7. It has a peculiar odour when breathed upon, or handled with moist fingers. In its ordinary state and at common temperatures it is tough, but becomes brittle when its temperature approaches that of fusion, which is about 770°. At a temperature between 220° and 300°, it is ductile and malleable. If slowly cooled after fusion, its fracture is very crystalline.

A surface of clean zinc exposed to dry air remains bright; in damp air it tarnishes. Under water it becomes enfilmed with hydrated oxide, or carbonate. At common temperatures it does not decompose water, but it does so at a red heat, or in the presence of acids. The energy with which zinc is acted on by dilute sulphuric acid is greatly dependent upon the purity of the metal: when perfectly pure, the action is feeble; but when it contains other metals, it becomes rapid, owing to a galvanic action. Zinc, in consequence of its lightness and cheapness, is much used for roofing, gutters, and chimney-tops; but it should not be riveted with copper or iron, the contact of which accelerates its destruction by electric action.

The great attraction between zinc and oxygen is shown by the facility with which many of the other metallic oxides, in solution, are reduced to the metallic state by its means. Its important electro-generative power in voltaic arrangements, must also be referred to this cause.

The only salifiable oxide is obtained by intensely heating the metal exposed to air, when its vapour takes fire, burns with a very bright flame, and forms a white flocculent tasteless substance, formerly called *nihil album*, *philosopher's wool*, and *flowers of zinc*. Zinc-leaf may also be inflamed by a spirit-lamp, and will continue to burn brilliantly even when removed from the flame. For pharmaceutical use, oxide of zinc combined with the carbonate is procured by decomposing a hot solution of sulphate of zinc by carbonate of soda. It is commonly met with in the form of a white powder, and is much used as a pigment, and in medicine as a tonic, and external application. Sir William Burnett's *disinfectant liquid* and preservative against dry rot is a strong solution of *chloride of zinc*: it is an acrid poison.

Sulphate of zinc, or white vitriol, is used in astringent lotions, and also as an emetic. Two important native compounds of zinc, BLENDE and CALAMINE, are described under those heads.

Zinked Iron; *Galvanised Iron*.—Plates of hot iron dipped into melted zinc acquire an appearance in some measure like that of tin-plate, for which they are a valuable substitute, inasmuch as the iron is prevented from oxidation by the electrical relations of the metals. Hurdles, fences, and all out-of-door iron-work, as well as implements used in damp situations, and employed in contact with water, may be thus defended. The wires of electric telegraphs are also usually of zinked iron. The zinking of iron is generally per-

formed by dipping the iron, previously well cleaned, into melted zinc, the surface of which is covered with sal-ammoniac to prevent oxidation, and so to enable the iron to become thoroughly wetted, as it were, with the zinc. The zinc is fused in large wrought-iron vessels, placed over proper furnaces; and after the frequent dippings of the iron articles, there is ultimately found at the bottom of the melted metal a quantity of a granular alloy of zinc and iron. The process is not applicable to the generality of vessels used for culinary purposes, in consequence of the contaminations by oxide of zinc which would often ensue, especially with acidulous liquors. In using zinked iron, care should be taken that where nails or rivets are required, they should also be coated with zinc. [Bell Metal; Brass; Bronze.]

Zinc Bloom. A hydrated carbonate of zinc or a mixture of carbonate of zinc with the hydrous oxide, resulting from the decomposition of Calamine. It occurs in white, yellowish or greyish incrustations, or reniform earthy masses, at Bleiburg and Raibel in Carinthia, also at Santander in Spain.

Zinc Spar. [Smithsonite.]

Zinc White. The product of the combustion of zinc in air. It is a white powder forming an excellent paint where mixed with the requisite proportions of oil and turpentine. The paint must not be too thin, or it will not cover; nor must the oil be in excess, or it will dry of a brownish tint.

Zincamide. A white solid obtained by the substitution of zinc for one-third of the hydrogen in ammonia.

Zincethyl. A colourless volatile liquid, composed of zinc and ethyl. It has powerful affinities for oxygen, igniting spontaneously on exposure to air. It is formed by heating zinc with iodide of ethyl under pressure.

Zincite. Native oxide of zinc found with Franklinite and Calc Spar at Franklin and Stirling Hill in New Jersey. Its colour is owing to the accidental presence of a small quantity of oxide of manganese.

Zinckenite. [Zinkenite.]

Zingiber (Gr. ζιγγίβερις). This name is now adopted by botanists to designate the typical genus of *Zingiberaceæ*, which consists of herbaceous Indian plants, with creeping jointed woody rootstocks, from which are sent up, every year, stems surrounded by sheathing leaves arranged in two ranks, cone-shaped spikes and flowers protected by bracts. The distinguishing features of the flowers are that the lateral inner lobes of the corolla are absent, and that the filament is prolonged beyond the anther in the form of a long beak.

The most important species is called *Z. officinale*, the rhizomes of which furnish the well-known spice called Ginger. The plant is largely cultivated in the East and West Indies, as well as in Africa and China. It is supposed that there are two varieties, one producing darker-coloured rhizomes than the other, this difference in colour being independent of the mode of preparation. The young rhizomes preserved in syrup are imported from the West Indies and China, and form the conserve known as preserved ginger, that imported from the West Indies being preferred to the Chinese kind.

The dried rhizomes or (as they are called in commerce) *races* are in the West Indies prepared for use when they are about a year old. They are then dug up, cleansed, scraped, and dried in the sun, and in this state form the uncoated ginger of the shops; but when the outer skin is not thus removed, the ginger is called *coated*, and has a dirty appearance. The softer kinds of ginger are preferred by the merchants, the hard shrivelled inferior kinds being used for grinding. The darker kinds of ginger are sometimes bleached by exposure to the fumes of chloride of lime or burning sulphur. East Indian gingers are not so largely imported or so highly esteemed as the West Indian kinds, the latter being less liable than the former to the attacks of worms. African ginger is imported in small quantities from Sierra Leone, while China exports only the preserved ginger already mentioned.

Zingiberaceæ (Zingiber, one of the genera) or **Scitamineæ.** A natural order of herbaceous monandrous Endogens, inhabiting the tropics, and characterised by its solitary stamen with a two-celled anther, and the presence of the vitellus around the embryo. The group is distinguished from *Musaceæ*, by the latter having five or six stamens, with a calyx and corolla of the same texture; from *Iridaceæ*, by two of the stamens being either deformed or abortive; and from *Marantaceæ*, by the single stamen being placed opposite to the labellum or anterior division of the inner series of the corolla, and proceeding from the base of the posterior outer division, and having only one cell. Cardamoms are the seeds of several plants of this order, which are, however, principally valued for the aromatic stimulating properties of the root or rhizome; such are found in Ginger (*Zingiber officinale*), Galangale (*Alpinia racemosa* and *Galanga*), and Zedoary (*Curcuma Zedoaria* and *Zerumbet*). Turmeric, a substance half dye and half condiment, is the powder of the rhizoma of *Curcuma longa*.

Zinkenite. A native sulphantimonite of lead, composed of 40 per cent. of sulphide of lead and 60 sulphide of antimony. It occurs in bright steel-grey six-sided prisms terminated by low six-sided pyramids at the antimony mine of Wolfsberg, near Holberg in the Harz. Named after its discoverer, Zinken.

Zinnwaldite. A variety of Lithia-Mica (*Lepidolite*) from Zinnwald.

Zinzeyd. A Persian name for the fruit of *Elæagnus orientalis* as an article of dessert.

Zippeite. A native sulphate of Uranium (named after Professor Zippe), of which there are two varieties, one containing copper, of which the other exhibits no trace. It has been found in Cornwall at the Callington tin-mine, at

Carharrack near St. Day, at the Withiel iron-mine, at Restormel, Huel Edward near St. Just, and at St. Michael's Mount, coating Mica.

Zircon. A silicate of zirconia found in the sand of the rivers of Ceylon [HYACINTH; JARGOON], in the syenite of Norway, &c., also at Strontian in Argyleshire, the isle of Harris in Sutherlandshire, and in the auriferous streams of the Croghan Kinshela mountain in Ireland.

Zircon occurs in crystals, generally square four-sided prisms terminated by four-sided pyramids, and also in grains, sometimes white, but more frequently red, brown, yellow, green, or grey. The colourless or slightly smoky kinds are called *Jargoon*; the bright red, *Hyacinth*, and the greyish or brownish, *Zirconite*.

When of a fine colour and transparent, these are sometimes used in jewellery.

Zirconite. A greyish or reddish-brown variety of *Zircon* found at Minsk in the Ural, and also at Scalpay in the island of Harris, one of the Hebrides.

Zirconium. The metallic base of *zirconia*, an earth discovered in 1789 by Klaproth in the jargon or zircon of Ceylon. Zirconium has only been obtained in the form of a black powder, which when heated in the air burns into the oxide. The salts of zirconia are distinguished from those of alumina and glucina by being precipitated by all the pure alkalies, and by being insoluble when they are added in excess. Its equivalent is 34, and the formula of its oxide Zr_2O_3.

Zizania (Gr.). A genus of grasses, the most interesting species of which is the *Z. aquatica* or Canadian rice, a well-known plant of North America, where the large seeds yield a considerable amount of food to the wandering tribes of Indians, and also feed immense flocks of wild fowl. It is sometimes called *Hydropyrum esculentum*.

Zizyphus (Gr. *ζίζυφον, the jujube-tree*). The Jujube or Lotus genus, a rather extensive group of *Rhamnaceæ*, having a wide geographical range, abounding, however, principally on the borders of the tropics in the Old World. The fruits of several species have an agreeable flavour. Those of *Z. vulgaris* are commonly eaten, both in a fresh and dried state, in the countries bordering on the Mediterranean, and afford the Jujube fruits of the shops; they are rather acid when fresh, but the dried fruits are more agreeable, and are given to allay cough. The lozenges sold as Jujubes are commonly but erroneously said to be flavoured with them. *Z. Jujuba*, an Indian species, yields an excellent dessert-fruit, and is largely cultivated by the Chinese, who recognise a great number of varieties, differing in the shape, colour, and size of the fruits. Those of one variety are called Chinese Dates, from their resemblance to dates. Some of them are sold in the market under the name of Japonicas. *Z. Lotus* is one of the many plants supposed to have yielded the seductive sweet fruits from which the ancient LOTOPHAGI took their name. Another African species, *Z. Baclei*, is the Lotus mentioned by Mungo Park as being used for making into bread, which has the taste of gingerbread, and also for the preparation of a pleasant beverage.

Zoanthus (Gr. *ζωός, living*, and *ἄνθος, a flower*). The name of a genus of Polypes, comprehending those which possess the complex structure of the *Actiniæ*, but consist of different individuals adhering to a common fleshy basis, in which calcareous spicules are sparingly scattered.

Zocle. [SOCLE.]

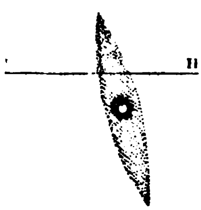
Zodiac (Gr. *ζωδιακός*, from *ζώδιον*, dim. of *ζῷον, an animal*; because the constellations of the ecliptic are for the most part represented in celestial charts by the figures of animals). An imaginary zone or belt in the heavens, extending to about 8° or 9° on each side of the ecliptic, which divides it in the middle. No use is made of the zodiac in astronomy; the name only indicates that region of the heavens within which the apparent motions of the sun, moon, and all the greater planets are confined. Three of the new planets, Juno, Ceres, and Pallas, have inclinations which exceed the limits of the ancient zodiac, and are therefore sometimes called *extra-zodiacal* planets; but Vesta is also sometimes included in the same description. [PLANET.]

The zodiac is divided into twelve equal parts, called *signs*; which are designated by the names of the constellations with the places of which the signs anciently corresponded. They are, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces. The signs are counted from the vernal equinox, one of the points in which the equator intersects the ecliptic; whence, in consequence of the regression of the equinoctial points, their position with respect to the constellations or fixed stars is greatly different from what it was in remote ages. Some time prior to Hipparchus, the first points of the constellations Aries and Libra corresponded to the vernal and autumnal equinoxes; those of Cancer and Capricorn to the summer and winter solstices: at present, the difference is about 30°. The vernal equinox now happens in the constellation Pisces, the summer solstice in Gemini, the autumnal equinox in Virgo, and the winter solstice in Sagittarius; but the vernal equinox always corresponds to the first point of the sign Aries, the summer solstice to the first of Cancer, and so on. On this account it is necessary to distinguish between the *signs* of the zodiac, which follow the motions of the equinoctial points, and the *constellations* of the zodiac, which are immovable in the celestial sphere.

It has been supposed that the constellations of the zodiac were invented in Egypt in a very remote age, and that they had reference to the divisions of the seasons and the agriculture of that country at the time of their invention. If we go back to a period of about 4,500 years, the constellations Aquarius and Pisces, at the season of the overflow of the Nile, would be diametrically opposite to the sun, and would

consequently rise at sunset. Virgo, usually represented as a woman with an ear of corn in her hand, would be the constellation rising at sunset in the time of the harvest in Egypt. Such conjectures, however, it is easy to conceive, are at best extremely uncertain. (Dupuis, *Mémoire sur l'Origine du Zodiaque*; Biot, *Recherches sur l'Astronomie Egyptienne*; Montucla, *Histoire des Math.* tom. i.; Bailly, *Hist. de l'Astr. Ancienne.*)

Zodiacal Light. In Astronomy, a faint nebulous aurora which surrounds the sun in the plane of its equator. This curious phenomenon was observed by Kepler, who supposed it to be the solar atmosphere; but it was first accurately described by Dominic Cassini, who gave it the name by which it is now known. It is visible immediately before sunrise or after sunset, in the place where the sun is about to appear or has just quitted in the horizon. It has a flat lenticular form, as represented in the annexed figure, extending from the horizon HH obliquely upwards, and following the course of the ecliptic, or rather of the sun's equator. For this reason it is scarcely visible in our latitudes, excepting in those seasons when the plane of the sun's equator is most nearly perpendicular to the horizon. The most favourable times for observing it are in the months of April or May, in the evening, or at the opposite season of the year before sunrise. At other times, the plane of the solar equator being more oblique, and the luminous pyramid inclined in the same degree, it rises so little above the horizon that its light is effaced by the atmosphere of the earth. The apparent angular distance of its vertex from the sun varies, according to circumstances, from 40° to 90° or 100°, and the breadth of its base perpendicular to its axis from 8° to 30°. It is extremely faint and ill-defined, at least in this climate; though it is better seen in tropical countries.



Many opinions have been entertained respecting the nature and cause of this singular phenomenon. Cassini thought it might proceed from the blended light of an innumerable multitude of little planets circulating about the sun, as the Milky Way owes its appearance to the light of agglomerated myriads of stars. Euler endeavoured to prove that it proceeds from the same causes which produce the tails of comets. Kepler had ascribed its appearance to the solar atmosphere; and the same hypothesis was adopted by Mairan and others, till it was shown by Laplace to be untenable for the following reasons: In the first place, the solar atmosphere cannot extend beyond the distance at which the centrifugal force would be balanced by the attraction; but this point lies far within the orbit of Mercury, the greatest elongation of which is 28°, whereas the zodiacal light has been observed to extend to 100° from the sun. In the second place, in order that the spheroid of the solar atmosphere may be in equilibrium, the ratio of the equatorial to the polar axis cannot exceed that of 3 to 2; whence its form would not correspond with the lenticular appearance of the zodiacal light. Sir John Herschel remarks, that 'it may be conjectured to be no other than the denser part of that medium, which, as we have reason to believe, resists the motion of comets; loaded, perhaps, with the actual materials of the tails of millions of those bodies, of which they have been stripped in their successive perihelion passages. An *atmosphere* of the sun it cannot be.'

According to the most recent hypothesis of Mayer and William Thomson, the zodiacal light has been held to consist of a vast number of meteorites which circulate around the sun, and are gradually falling into that luminary, their impact contributing to restore the solar heat and light lost by radiation. But considerable doubts have been thrown on this theory, and moreover some observers who have had ample opportunities of observing the phenomenon in the tropics, where it is generally to be seen in all its splendour, affirm that the ring instead of being within the earth's orbit is actually outside it. In fact, M. Liais, who has observed it with the greatest attention in Brazil, asserts that he has often seen it spanning the sky from west to east. If this be confirmed by subsequent observers, the fact either that it really lies outside the earth's orbit, or that it is of considerable eccentricity, will be established.

Zohac. In Mythology. [Thraetana; Vritra.]

Zohar (Heb. *splendour*). A Jewish book, highly esteemed by the rabbis, and supposed to be of great, though altogether unascertained, antiquity. It consists of cabalistical commentaries on Scripture, especially on the Pentateuch. It has been translated into Latin (ed. 1680).

Zoisite. A silicate of alumina and lime, formerly considered a variety of Epidote, and named after its discoverer, the baron von Zois. It is said to occur in fine crystals of a greyish-brown or olive colour at Hollyhill near Strabane, Tyrone.

Zollverein (Ger. *toll-union*). Up to the year 1837, the inconveniences which affected trade in consequence of the various customs duties levied at the frontier of the numerous German states, were exceedingly vexatious and mischievous, besides which the costs and charges of collecting the revenue were exceedingly large. At the instance, therefore, of Prussia, on August 23, 1837, at a convention held at Munich, a number of states entered into a union for fiscal purposes. It was agreed that fixed taxes should be levied on commodities at their entrance into any parts of the German frontier which should be occupied by any of the states taking part in the convention, that the pro-

ceeds should be paid into a common fund, should be distributed among the several states forming the convention, on the basis of population, and that the arrangements should be subject to subsequent and periodical revision.

The establishment of the Zollverein was an act of great financial wisdom, and reflects great credit on the intelligence and sagacity of Prussia. But no states in Northern Germany at first entered into the arrangement, and for a considerable time the effectual working of the plan was much impeded. In time, the great inconveniences which ensued to states which excluded themselves from the Zollverein, amounting in effect to considerable penalties, brought the malcontents gradually round, and at the beginning of the year 1866 all the North German communities and most of the Southern were enrolled. It is not likely, since the face of Germany must needs be changed by the events of the late war, that the extent of the Zollverein is likely to be narrowed, or its efficiency impaired in future.

In order to facilitate the estimate of taxes, an arrangement was entered into by which the North and South German currencies, the chief elements in which are the thaler and florin respectively, were mutually valued. According to the reckoning of the former, the *Nord Deutsche Währung*, the pound of fine silver is equal to 30 thalers; according to the latter, the *Süd Deutsche Währung*, it is equal to 45 Austrian and 52½ Rhenish florins; so that two North German dollars are equivalent to three Austrian and 3½ South German or Rhenish florins; or, to interpret these values in English money, the thaler, or North German dollar, is worth 2*s.* 10¾*d.*, the Austrian florin 1*s.* 11¼*d.*, the South German or Rhenish 1*s.* 7¾*d.*

The original members of the league were Prussia—North; Bavaria, Würtemburg, Baden, Hesse, Nassau, and Frankfort—South.

At the beginning of the year 1866, the Northern states were Prussia, Saxony, Hanover, Electoral Hesse, the grand duchy of Saxony, Saxe Altenburg, Saxe Gotha, Brunswick, Oldenburg, and Birkenfeld, the two Anhalts, the two Schwarzburgs, Waldeck, Pyrmont, the two principalities of Reuss, Schaunberg Lippe, and Lippe. The Southern were Bavaria, Würtemburg, grand duchies of Baden and Hesse, Saxe Coburg, Nassau, Schwarzburg Rudolstadt, Hesse Homburg and Frankfort.

Zomidine (Gr. ζωμός, *broth*). The aqueous extract of flesh: one of the substances giving the odour to meat-broth, and probably the same as OSMAZOME.

Zona Pellucida (Lat.). In Embryology, the external investment of the ovarian ovum in mammalia, which consists of a thick transparent membrane, and appears, under the microscope, as a bright zone or ring.

Zone (Gr. ζώνη, *a girdle or belt*). In Astronomy, a portion of the celestial sphere included between two parallel circles. In Geography, the terrestrial zones are the five broad spaces or belts into which the surface of the earth is divided by the two tropics and the two polar circles. The space included between the tropics is called the *torrid zone*; its breadth is equal to 47°, or twice the sun's greatest declination, and it is divided into two equal parts by the equator. That included between the tropic of Cancer and the arctic circle is called the *north temperate zone*; and that between the tropic of Capricorn and the antarctic circle, the *south temperate zone*. The breadth of each of these is 43°. The space between the arctic circle and the north pole is the *north frigid zone*; and that between the antarctic circle and the south pole is the *south frigid zone*. [EARTH; GEOGRAPHY.]

Zoography (Gr. ζῶον, and γράφω, *I write*). The description of animals.

Zooid (Gr. ζωοειδής, *like an animal*). A term used to denote organic bodies, sometimes free and locomotive, e. g. spermatozoa, which resemble but are not animals. It has been misapplied to parthenogenetic progeny, which, in whatever degree they may be like their parents or unlike them, are equally either animals or plants. Thus the *bud* of the oak-tree, as that of the Hydra-polype, is the *zooid* of each respectively.

Zoolatry (Gr. ζῶον, *an animal*, and λατρεία, *worship*). A term employed to denote that worship of animals which was the characteristic of the ancient Egyptian religion most remarked upon by foreigners.

Zoology (Gr. ζῶον, and λόγος). The science of animals. It teaches their nature and properties, their classification, and their order of succession upon and their distribution over the earth.

A knowledge of the nature of animals, as it implies that of their organisation, and of the functions and interdependencies of their component parts, constitutes the two great branches of zoology, called *Zootomy*, or comparative anatomy, and *Physiology*. The doctrine of the succession of species of animals upon the earth, as it relates principally to such as no longer exist, is included in a third branch of the science of animals, called *Palæontology*, with which is closely connected that which treats of the geographical distribution of existing species. The term *Zoology* is practically restricted to the science of the outward characters, habits, properties, and classification of animals.

A classification is essentially based on the ideas of likeness, unlikeness, and proportion in its subjects. When it is purposed to define, in a classification of animals, their different degrees of resemblance, a natural system is aimed at. When a classification is restricted to the enunciation of a few likenesses which may be most readily detected and most easily retained in the memory, it becomes an artificial system. A likeness extends as far as a character is common; and the more extended or common the property or structure on which such character is founded, the more important and essential it becomes as an element of the classification.

Zoologists having ascertained as many of the characters common to all animals as served to form their complex idea of an animal, have, in the next place, sought to discover the difference which, added to the idea or definition of the animal, would form logically the most extended species of that genus.

Such a difference or character is not to be detected by a superficial examination. Aristotle thought that he had found it in the blood, recognising as blood only the red-coloured nutrient fluid, like that which flows in the arteries and veins of man. His primary division of animals was therefore into Sanguineous and Exsanguineous animals; the *Enaima* and the *Anaima*. The Enaima were the beasts, birds, reptiles and fishes; and the Anaima, or bloodless animals, included all the lower species.

Nothing, perhaps, can show more forcibly the nature and amount of observation required to frame a good classification, and the value of the information concentrated in its exposition, than the great and long-continued deference paid to this early step in the classificatory branch of zoology, and the minute and extended researches needed for the elimination of its erroneous element. First, it was found that many of the Exsanguineous animals of Aristotle did actually possess blood, differing only in colour from that of the so-called Sanguineous species. This discovery, however, led only to a nominal improvement in the primary division of animals; the Enaima being *red-blooded* and the Anaima *white-blooded* animals. It was reserved for Cuvier, in the course of his minute dissections of the lower animals, to discover that an extensive class of worms had red blood circulating in a closed system of arteries and veins; and this discovery first materially affected the value of the character adopted by Aristotle for the primary groups of the animal kingdom.

Now, if scientific classification were really based on the idea of likeness alone, and the grouping together of individuals into kinds in forming a natural system were regulated by a consideration of their resemblances only, then the modification of the Aristotelian system involved in Cuvier's discovery would be merely an extension of the group Enaima at the expense of the group Anaima; and the Anellides, or red-blooded worms, must have been united with birds, fishes, and other Sanguineous animals. But the zoologist, in the formation of a natural system, has to be governed at every step by the idea of difference as well as by that of likeness. Coincident with the discovery above mentioned, was the perception that if the Anellides resembled beasts in the colour of their blood, they differed from them in most other essential points; and thus the circulating fluid was rejected as a ground for the primary groups of the animal kingdom, and other characters were eagerly sought for.

Lamarck conceived that he had discovered the best substitute for the Aristotelian primary character in the vertebral column; this structure being present in all the Enaima of Aristotle, and absent in all the Anaima. He proposed, therefore, the name of *Vertebrata* for the one class, and *Invertebrata* for the other. The defect of this primary division of the animal kingdom was soon perceived to arise from the neglect of a third fundamental idea in a classificatory science, viz. that of proportion, or relative value, in the primary groups; and in the attempt to remedy this defect, the important discovery was made, that the vertebral column was a modification of structure subordinately related to a particular condition of an organic system of much higher importance in the animal body than the skeleton, viz. the nervous system. A knowledge of the anatomy of this system hence became essential to the zoologist; and the result of a long series of minute and elaborate dissections was the detection of at least three modifications of the nervous system of equal importance with that in regard to which a skull and vertebral column are dependent and subordinate. Hence arose the proposition by Cuvier to divide the animal kingdom primarily into four provinces or subkingdoms; viz. *Vertebrata*, *Mollusca*, *Articulata*, and *Radiata*; or, as they have been termed, in accordance with the modifications of the nervous system respectively characterising them, *Myelencephala*, *Heterogangliata*, *Homogangliata*, and *Acrita*.

All previous primary divisions of the animal kingdom (if we except some of the schemes of classification of the animal kingdom by John Hunter, found among his manuscripts after his death—see Preface to Palmer's edition of his *Animal Economy*) had been proposed in ignorance of the true characters by which such groups exist in nature. They are, therefore, now abandoned by the common consent of naturalists, nor would anything be gained by quoting them in this place. Herein the Linnæan method is inferior to the Aristotelian system: the class *Vermes* of the *Systema Naturæ*, as it included the *Ostracoderma* and *Malakia* of Aristotle, afterwards the *Mollusca* of Cuvier, with the true *Vermes*, was a retrograde step in this branch of zoological science.

The subkingdom *Vertebrata*, or *Myelencephala*, is subdivided into classes, according to the modifications of the respiratory and circulating organs. These modifications are essentially four in number, which may be thus expressed:—

1. Lungs suspended freely in a thoracic cavity; subdivided into minute air-cells. Heart divided into four cavities; pulmonic and systemic circulations distinct.

2. Lungs adherent to the walls of a thoracic cavity, communicating with large air-cells in other cavities of the body. Heart with four cavities; pulmonic and systemic circulations distinct.

3. Lungs suspended freely in or attached to the parietes of a thoracic-abdominal cavity; not divided into minute air-cells. Heart with

four or three cavities; pulmonic and systemic blood mixed in the general circulation.

4. Gills for respiration, with or without lungs. Heart with two cavities, transmitting all the blood to the breathing organs.

The first condition of the respiratory and circulating organs coexists with a viviparous generation, and lacteal organs for the nourishment of the new-born young; whence the class was termed ZOOTOCA by Aristotle, and *Mammalia* by Linnæus; and the latter term is retained, because it expresses a character which is truly peculiar to the class. The total or partial clothing of hair, and the other organic coexistences which proclaim the naturalness of the group in question, are mentioned under the term MAMMALIA.

The second condition of the respiratory and circulating organs characterises the class of Birds. It is associated in this class with an oviparous generation, a covering of feathers, and those other modifications of the vertebrate type of structure which are detailed under the head of AVES. This is the most natural and circumscribed of all the groups of animals of corresponding value. Both mammals and birds differ from all other classes of animals in being warm-blooded: whence they have been combined to form a group called *Hæmatotherms*.

The condition of the circulating and breathing organs which characterises the third class of vertebrate animals, called Reptiles, is associated with cold blood, and a covering of scales, bony plates, or a naked skin. Their generation is oviparous or ovoviviparous: the other characters are given under the head REPTILIA.

Fishes, besides breathing by gills, and having a heart composed of a single auricle and ventricle, have the skin defended by scales, or by bony plates, or are naked. They are likewise oviparous or ovoviviparous; and, with a few exceptions, as the tunny, the temperature of their blood corresponds with that of the surrounding medium. They are exclusively aquatic; and their general characters and classification are given under the heads ICHTHYOLOGY and PISCES. The two classes of fishes and reptilia are grouped together under the larger division of HÆMATOCRYA.

The subkingdom *Mollusca*, or *Heterogangliata*, is characterised by a ring of nervous matter surrounding the gullet, whence the nerves radiate, often unsymmetrically, to different parts of the body. There is a ganglion or little brain below the gullet, and sometimes also above that tube: the nerves of the body are generally connected with one or more detached ganglions. The form of the body corresponds with the disposition of the nervous system, and is often unsymmetrical; it is generally soft, covered with a mucous skin, and destitute of jointed limbs. In one class (*Cephalopoda*), in which the supraœsophageal nervous mass is large, it is protected by a cartilaginous cranium; but this is absent in other Mollusca, and a vertebral column exists in none. Many species have for their skeleton a calcareous plate or plates, called *shells*, developed by the skin. [CONCHOLOGY.] The animal functions are feebly enjoyed in the *Heterogangliate* subkingdom. Distinct organs of hearing and smell have as yet been found only in the highest class (*Cephalopoda*); the eyes are reduced to mere rudiments in the group next in subordination (*Gastropoda*); and the head is altogether wanting in the three lower classes, thence collectively called *Acephala*. The machinery of the organic functions, on the other hand, is largely and completely developed. Every mollusc has a heart, and a closed system of arteries and veins: in the higher Cephalopods the circulating system is physiologically as perfect as in the highest Vertebrates, and the heart is anatomically more complicated. An organ of respiration is never wanting; but it presents this character, that whereas in the *Vertebrata* it communicates with the mouth, in the *Mollusca* it is connected with the opposite termination of the alimentary canal. The *Mollusca* are either Diœcious or Hermaphrodite.

The primary division of *Mollusca* is, according to the presence or absence of a head, into the *Encephala* and *Acephala*.

The Encephalous Molluscs are divided, according to their locomotive organs, into the classes CEPHALOPODA, GASTROPODA, and PTEROPODA; the Acephalous Molluscs, according to their respiratory organs, into LAMELLIBRANCHIATA, PALLIOBRANCHIATA, and HETEROBRANCHIATA: the two latter classes are more commonly called BRACHIOPODA and TUNICATA. [MALACOLOGY.]

The third primary division of the animal kingdom, viz. the *Articulata*, is as well characterised, Cuvier states, as that of the *Vertebrata*. 'The skeleton is not internal, as in the latter; neither is it annihilated, as in the *Mollusca*. The articulated rings which encircle the body, and frequently the limbs, supply the place of it; and as they are usually hard, they furnish to the powers of motion all requisite points of support; so that we have here as many kinds of locomotion as among the *Vertebrata*. This external position of the hard parts, with the internal position of the muscles, reduces each articulation to the form of a sheath, and allows it but two kinds of motion, unless the limbs be united by flexible membranes, or fit into one another; and then their motions are more various, but have not the same force.

'The systems of organs in which the *Articulata* resemble each other the most is that of the nerves. Their brain, which is placed above the œsophagus and furnishes nerves to the parts adhering to the head, is very small. Two cords, which embrace the œsophagus, are extended along the abdomen, and united at certain distances by double knots or ganglia, whence arise the nerves of the body and limbs.

'Each of these ganglia seems to fulfil the

functions of a brain to the surrounding parts, and to preserve their sensibility for a certain length of time when the animal has been divided. If to this we add that the jaws of these animals, when they have any, are always lateral, and move from without inwardly, and not from above downwards, and that no distinct organ of smell has hitherto been discovered in them, we shall have expressed all that can be said of them in general.' The existence, however, of the organs of hearing, the presence, number, and form of those of sight, the kind of respiration, the condition of the organs of circulation, and the colour of the blood, present great differences, which characterise the subdivisions or classes of the Articulate or Homogangliate subkingdom.

These classes are: ARACHNIDA, INSECTA, CRUSTACEA, CIRRIPEDIA, and ANELLATA.

The first three are combined by Latreille into a large group, called *Condylopoda*, in reference to their possessing articulated members; but these are likewise possessed by the *Cirripedia*, which, although placed by Cuvier in the Molluscous subkingdom, are proved by their nervous system and metamorphoses to be essentially *Articulata*, nearly allied to the Crustaceans. With the Annelides the *Entozoa* are allied by close transitions: the *Bryozoa* have like relations to the *Tunicata*.

The Radiated, or fourth primary division of animals in the system of Cuvier, is so called because the low-organised species composing it agree, Cuvier says, in having their parts arranged round an axis, and on one or several radii, or on one or several lines extending from one pole to the other. The nervous system, when traces of it have been visible, is also arranged in radii. For classes of still lower organisms, sometimes ranked with animals, sometimes with plants, but not raised to the characters of either, see ANIMAL. The following table of the primary groups and classes of the animal kingdom is the most convenient:—

Kingdom ANIMALIA.

Subkingdom *Vertebrata*.

Hæmatotherma { *Mammalia*, *Aves* }

Hæmatocrya { *Reptilia*, *Pisces* }

Subkingdom MOLLUSCA.

Cephalopoda	*Brachiopoda*
Gastropoda	*Conchifera*
Pteropoda	*Tunicata*

Subkingdom ARTICULATA.

Insecta	*Cirripedia*
Arachnida	*Annelida*
Crustacea	*Entozoa*

Subkingdom RADIATA.

Echinodermata	*Anthozoa*
Acalephæ	*Hydrozoa*.

Zoonomy (Gr. ζῶον; νόμος). The branch of science treating of the laws of animal life.

Zoophytes (Gr. ζωόφυτον, *an animal plant*). The name given by Cuvier to his fourth and last primary division or subkingdom of animals. By Linné it was applied in a more restricted sense to an order of *Vermes*, comprehending those beings which were supposed by him to share the natures of both animal and plant. Mr. Hatchett's dissertation upon these subjects, in the *Philosophical Transactions* for 1800, contains nearly all the chemical information which we have respecting them. From their composition they may be arranged into four classes: 1. Those which consist almost entirely of carbonate of lime and gelatine. They are perfectly soluble (with effervescence) in muriatic acid, and the solution yields slight traces only of animal matter: when heated red hot, they evolve but little smoke or odour, and leave quicklime. Common white coral (*Madrepora virginea*) is an instance of this variety. 2. Those which, like the former, have carbonate as their hardening principle, but which when steeped in muriatic acid are less rapidly acted on, and leave membranous or cartilaginous films, and which, when heated, exhale smoke and the odour of burnt bone; these, therefore, consist of carbonate of lime, gelatine, and albumen. Such are the *Madrepora ramea* and the *Madrepora fascicularis*. The *Isis hippuris* is a curious variety of this class, in which separate portions of var. 1 are united by cartilaginous joints. 3. This class includes the *Gorgonia nobilis*, or red coral, the *Tubipora musica*, and some other varieties; the earthy part of which is not merely carbonate of lime, but contains a portion of phosphate of lime, whilst the animal part resembles class 2. 4. This class includes the various sponges. Some of these consist almost exclusively of what may be called *animal matter*, i. e. of a peculiarly organised albumen, with a trace of gelatine; others are hardened by abundant silicious or calcareous spiculæ. Mr. Hatchett has pointed out the resemblance which exists among the first three classes to porcellaneous shell, mother-of-pearl shell, and the crustaceous coverings of the crab and lobster.

Zoospores (Gr. ζωός, *living*, and σπορά, *seed*). A name given to the active spores of *Algæ*, belonging both to the green and dark-spored series. Their activity depends either on a general coat of short cilia on a circle at one extremity, or on two or more lash-like cilia variously disposed. The occurrence of spores endowed with apparently voluntary motion was formerly considered so surprising, that it was either rejected as unworthy of credit, or the organisms which produced them were considered as animals. It is now, however, generally allowed that there is no essential difference between animal and vegetable life, and that therefore the usual indications of either are not to be regarded as decisive of the especial kingdom to which beings belong in which they are manifested. Zoospores so long as they are free have indeed a great likeness to *Infusoria*, but as soon as they have found a fit resting-

place all traces of motion cease, and their offspring comports itself as a vegetable.

Zootoca (Gr. ζωοτόκος, *viviparous*). In Zoology, the name given by Aristotle to the class termed Mammalia by Linnæus. The name has, however, been restricted by some modern naturalists to a sub-genus of lizards distinguished by their viviparous generation.

Zootomy (Gr. ζῶον, and τέμνω, *I cut*). The branch of anatomical science which relates to the structure of animals generally. [Anatomy, Comparative.]

Zorgite. A name given to the varieties of Clausthalite in which part of the lead is replaced by cobalt and copper. [Raphanosmite; Tilkerodite.]

Zoroaster, more properly **Zarathustra.** The great legislator and prophet of the Bactrians, called by Plato a son of Oromazes [Ormuzd]. Of his personal history nothing is known. By some, Zoroaster is said to be a contemporary of Darius Hystaspis; by others, he is placed many hundred or even many thousand years earlier. (Gibbon, *Roman Empire*, ch. vii. with Milman's notes.) The Iranian lawgiver must therefore be placed in the class which includes Lycurgus, Numa, Romulus, Servius Tullius, Pythagoras, Zaleucus and Zalmoxis. The religion of Zoroaster, Dualism [Ahriman], was restored as the national faith of Persia by the Sassanidæ, 'the only instance, perhaps, of the vigorous revival of a pagan religion.' (Milman, *Hist. of Christianity*, book iii. ch. i.)

The Zoroastrian system is embodied in the Zend Avesta.

Zosteraceæ (Zostera, one of the genera). A small order of Endogens sometimes regarded as first of the group Fluviales. It consists of marine plants resembling seaweeds and living among them, but bearing long grass-like sheathing leaves, and perfect flowers enclosed in the sheathing bases of the leaves. They are found abundantly in the seas which border Europe, Asia, and North Africa, and also in the West Indies and Australia.

The genus *Zostera*, comprising two species, consists of marine herbs, usually growing in shallow water near the edges of the sea, their long rooting stems creeping along in the sand or mud, and sending up slender erect branches, bearing long narrow grass-like alternate leaves, sometimes forming such dense masses as to impede the passage of boats. *Z. marina*, the common Sea-wrack, Grass-wrack, or Grass-weed, has leaves varying from one to several feet in length, and rarely more than a quarter of an inch broad. These are commonly used for packing, and by upholsterers for stuffing mattresses and cushions, being sold for that purpose under the name of *Ulva* or *Alva marina*. They contain a small amount of iodine, and a considerable quantity of potash.

Zouaves. A class of soldiers in the French military service, whose name is said to be derived from that of a native tribe in Algeria. Originally the light infantry thus called were levied among the natives of that country; and their first organisation is attributed to General Clausel (October 1830, immediately after the conquest). Afterwards the corps was gradually, and is now exclusively, recruited in France, and consists chiefly of men transferred from the line to it as a corps d'élite. The natives are now enrolled in other corps, the 'Kabyle' infantry, &c., popularly known as Turcos. The French Zouaves first rose into European reputation in the Crimean war.

Zuinglians. In Ecclesiastical History, the followers of Zuinglius, the most advanced of the reformers of the age of Luther. Zuinglius regarded the sacraments as mere signs and symbols, and maintained that original sin was nothing more than a malady or evil tendency, in no degree involving guilt. He thus abandoned the notion of transmitted guilt, and the idea that children dying unbaptised can suffer for the lack of that which it was not in their own power or choice to obtain. With this doctrine he also abandoned of necessity the tenet of exclusive salvation, which was vehemently maintained by Luther and Calvin, and in all other reformed confessions. In the confession of faith written shortly before his death, Zuinglius describes that assembly of all the saints, the heroic, the faithful, and the virtuous, in which every upright and holy man who has ever lived will be present with his God. On reading this confession, Luther said that he despaired of the salvation of Zuinglius, while his practical advice was to hunt down the Zuinglians as mad dogs. It was only a natural consequence, that while Luther propounded and acted on this sweeping theory, Zuinglius opposed himself to the idea of persecution, and died fighting in the battle-field in defence of his liberal principles. (Hallam, *Literary History*, vol. i.; Lecky, *History of Rationalism*.)

Zumology (Gr. ζύμη, *leaven*, and λόγος). The doctrine of fermentation.

Zumometer or **Zumosimeter** (Gr. ζύμη, and μέτρον, *a measure*). An instrument intended to show the degree to which fermentation has proceeded in different fermenting liquors. [Saccharometer.]

Zurlite. A variety of Mellilite of an asparagus-green colour inclining to grey, which occurs at Vesuvius, generally in large rectangular prisms. Named after Signor Zurlo.

Zwieselite or **Zwiselite.** A variety of Iron-Apatite or phosphate and fluoride of iron and manganese, found at Zwiesel in Bavaria.

Zygadite (Gr. ζυγόν, from its occurrence in twin-crystals). A silicate of alumina and lithia found in thin tabular prisms and in twins like Albite, and of a reddish or yellowish-white colour near Zellerfeld in the Harz.

Zygæna (Gr. Ζύγαινα, the name of a fish in Aristotle). A genus of Cartilaginous fishes of the Squaloid or Shark tribe, remarkably characterised by the extreme breadth and flatness of the head, the sides of which extend outwards at right angles with and far beyond the body, just as the head of a hammer is placed on the handle: the eyes are placed at

the lateral margins of the head. The term *Zygæna* has also been applied by Tchsenheimer to a genus of *Lepidoptera*.

Zygænocephalus (Gr. ζύγαινα; κεφαλή, *the head*). A species of frugivorous bat allied to Pteropus, which has been described by Mr. A. Murray, from the Cabra river, Western Africa. The head is swollen and the nostrils inflated, so as to give to this remarkable cheiropterous form the appearance of having the head of a hippopotamus.

Zygantrum (a word coined from Gr. ζύγον, and ἄντρον, *a hole*). The articular cavity at the back part of the neural arch of the vertebræ of serpents and some lizards, which receives the zygosphene.

Zygapophysis (Gr. ζύγον; ἀπόφυσις, *a process*). The articular or oblique process of the vertebra, by which it is connected with the adjoining vertebræ.

Zygodactyles (Gr. ζύγον, and δάκτυλος, *a finger*). The name given by M. Temminck to an order of climbing birds, including those which have the toes arranged in pairs, two before and two behind; corresponding to the *Scansores* of Cuvier.

Zygoma (Gr. ζύγωμα, from ζύγον, because it transmits the tendon of the temporal muscle like a yoke). The cavity under the *zygomatic* process of the temporal bone. Hence, also, the term *zygomatic muscles*.

Zygophyllaceæ (Zygophyllum, one of the genera). A natural order of hypogynous Exogens, nearly allied to *Oxalidaceæ*, from which they differ in many characters; to *Simarubaceæ*, with which they accord in the stamens springing from the back of an hypogynous scale; and to *Rutaceæ*, from which they are distinguished by the leaves being constantly opposite, with lateral or intermediate stipules, generally compound, and always destitute of pellucid dots. They are shrubs or herbs, widely dispersed over the tropical and warmer parts of the globe, but occurring sparingly in temperate climates. They are characterised by their opposite stipulate leaves, their few-seeded finally apocarpous fruits, the pericarp of which does not laminate, and their albuminous seeds. The ligneous plants of this order are remarkable for their hardness. *Guaiacum*, or *Lignum Vitæ*, is one of them.

Zygosphene (Gr. ζύγον, and σφήν, *a wedge*). The wedge-shaped process from the fore part of the neural arch of the vertebræ of serpents and some lizards, superadded to the ordinary anterior zygapophyses, and articulated to a cavity in the antecedent vertebra.

Zymotic (Gr. ζυμωτικός, from ζύμη, *leaven*). In Medicine, diseases caused apparently by the reception into the system of a virus or poison, which is diffused through the frame, and operates upon it like a ferment or leaven. In the Registrar-General's Report, the following diseases are grouped together as *zymotic*: smallpox, measles, scarlatina, hooping cough, croup, thrush, diarrhœa, dysentery, cholera, influenza, purpura and scurvy, ague, remittent fever, infantile fever, typhus, metria or puerperal fever, rheumatic fever, erysipelas, syphilis, noma or canker, hydrophobia.

THE END.

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